NATIONAL MUSEUM OF VICTORIA

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THE JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF VICTORIA, AUSTRALIA.

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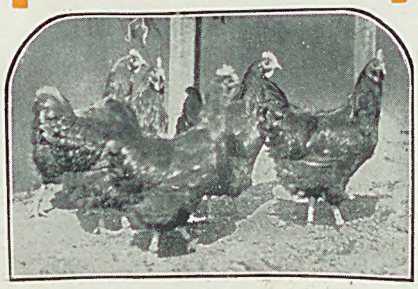

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Issued under the direction of the Hon. W. Slater, M.L.A., Minister of Agriculture.

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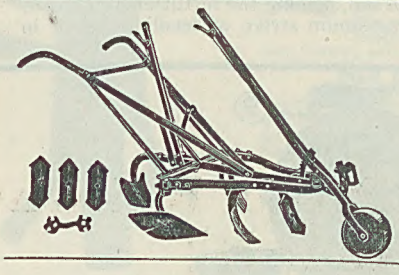

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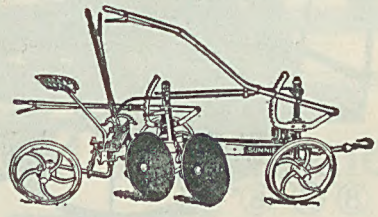

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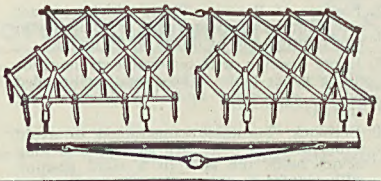

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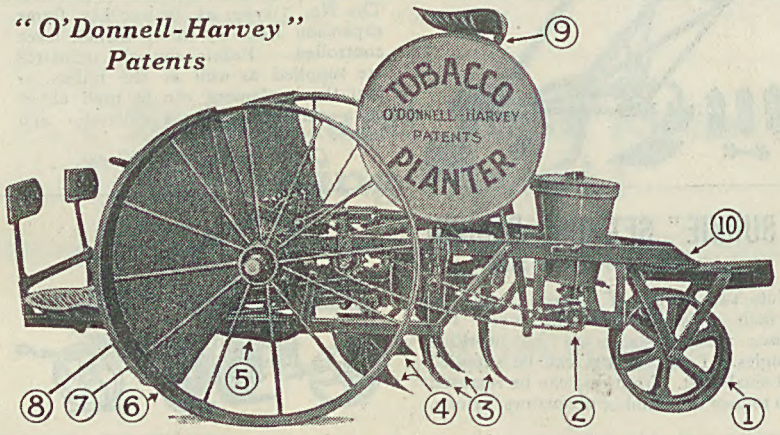

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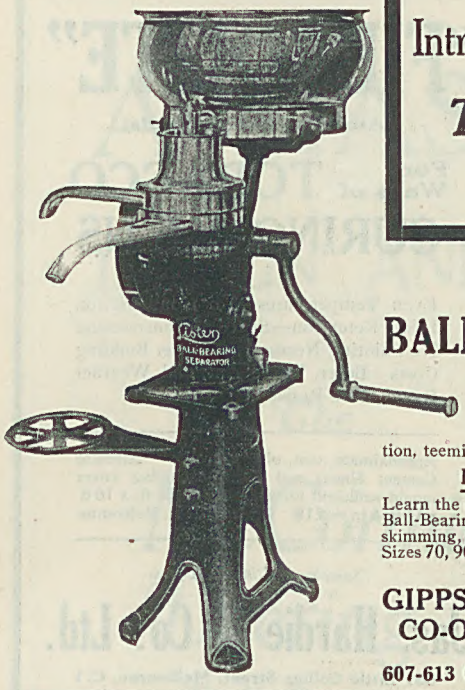

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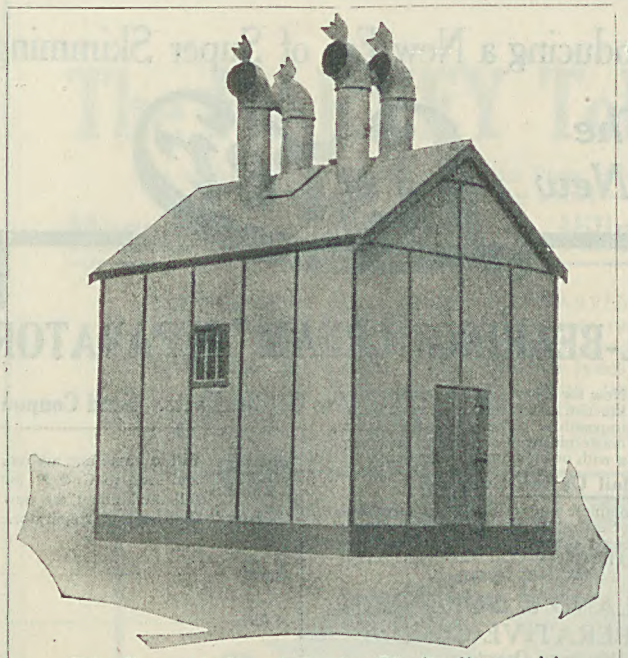

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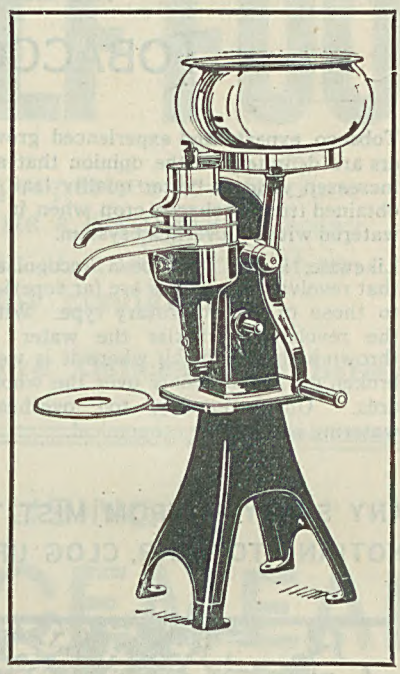

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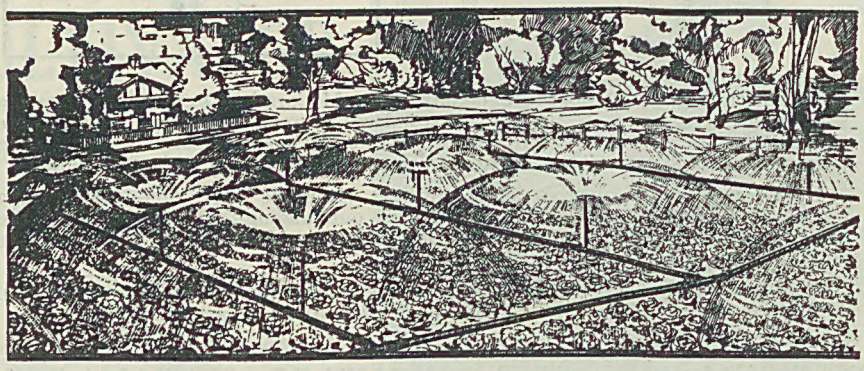

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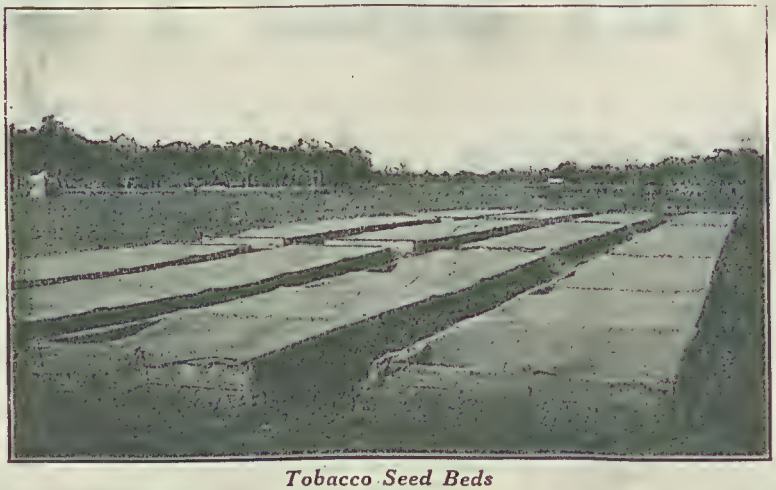

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The Journal of the DEPARTMENT of AGRICULTURE of VICTORIA

Wheat Breeding

The Production of New Varieties

By G. S. Gordon, Cerealist

THE production of new varieties of wheat is simple, but the creation of new varieties *of economic value* is a much more difficult matter. For this reason, it is advisable to define "new" varieties as those which are not only new to the State, but which, by their merit, have won their way to favour and are now grown in considerable area.

Progressive farmers are quite alive to the value of varieties that are more prolific and more resistant to disease and drought, since these offer a means of keeping down production costs and increasing cash returns, without adding to the labour of growing the crop. In view of the world economic situation, however, and particularly the low price of wheat, growers to-day are faced with a need for efficiency and economical production greater than has existed at any previous time.

It will be recognized, therefore, that the production of more prolific and generally suitable varieties is of vital importance to the wheat-grower. In fact, the use of these varieties is probably the quickest and most economical method of increasing the crop production of the State.

Crossing two wheats.

There are three methods by which these desirable new varieties may be obtained—

1. By introduction of varieties already available in other parts of the world.
2. By selection of superior (and sometimes "variant") plants which appear as "sports," &c., in existing varieties.
3. By crossbreeding or hybridization.

As to the first of these methods, introduction from other sources, it may be pointed out that there are about 100 varieties under more or less general cultivation in Victoria, and that possibly thousands of varieties are available from other sources. Those who are not conversant with the subject might think this number would be sufficient for all requirements. A brief study of the facts, however, shows the fallacy of this conclusion, and not only indicates the importance of breeding varieties suitable to our own general conditions, but suggests also that the varieties of the future may even be bred for the conditions of a particular district rather than the whole State.

Wheats introduced into Victoria from overseas have not proved of much value for general cultivation and often are quite unsuited to our requirements. Recent discoveries indicate that this is due largely to the varying length of daylight, according to latitude, and that we can hope to find useful varieties only in countries having a length of daylight similar to our own. For instance, the best English varieties, with a good reputation for prolificacy in the country for which they were bred, when grown here, prove too late in ripening and consequently suffer severely from the drying conditions of early summer. When, by means of electric light, the length of daily illumination is increased, these wheats stool less, and develop and ripen much earlier.

It is, of course, not feasible to illuminate our larger areas, but it is quite practicable to apply light to small plots for special purposes. A small bird-proof enclosure, fitted with electric light, is now in use at the Werribee Research Farm, and, by this means, it has been possible to compare the behaviour of both introduced and local varieties under varying periods of daily illumination, hasten the

Noting the characteristics of the resultant crossbreds.

The Crossbred wheats are planted out in "Long Rows".

development of late maturing types for crossing purposes, and grow two, and even three generations of plants in one year.

The Department is always ready to try out promising varieties from outside sources. Even if these are not of direct value to the grower, they sometimes have desirable characters such as disease resistance, which can be combined with the good qualities of our Australian wheats.

With the second method of improvement, i.e., selection, we do not *create* new types, but merely select plants showing desirable variations, and which have occurred spontaneously as "sports" or "mutants," or possibly from natural crossing in the variety. The special plants may be definitely variant to the variety in which they appear, or may vary only in regard to a single character, such as prolificacy, which is not readily noticeable. If "mutants," the new type usually breeds true and the trouble of "fixing" them is saved. By keeping the progeny of the selected plants isolated, and testing them against suitable standard varieties for some years, a strict comparison of each selection is possible, and their individual values are determined. Thus, wheats varying only in power to yield may be isolated, and, if worthy, can be multiplied for more extensive use.

Wheats which have originated as "selections" are Dart's Imperial, Penny, Turvey, Wannon, &c., but a more recent example is provided by a selection from one of the Werribee-bred wheats, Ranee. In appearance, the new selection (known at present as Ranee 4 H) shows little difference from the original strain which is now the second most extensively grown variety in the State, with well over half a million acres sown this year. In regard to yield, however, there is a very marked difference in favour of the new selection. In ten tests, over a period of six years at Werribee, Ranee 4 H has outyielded the original Ranee by 3.9 bushels per acre, and has also given increased yields in the departmental plots in various districts. Assuming that only half the increased yield obtained at Werribee was harvested over the area sown with the old Ranee this year, the new selection would give an extra yield of some 1,047,000 bushels, which, at only 2s. per bushel, would be worth over £104,000 to the growers. Ranee 4 H has replaced the original Ranee at the Research Farm, and seed is available to farmers, so that they may reap the benefit of its increased yielding capacity.

The third and most important method of producing new varieties, crossbreeding or hybridization, provides a certain means of improvement, for, by it, the desirable characters of both parents can be combined in one new variety, and undesirable characters eliminated. Crossbreeding causes the unit characters in the constitution of the parents to be split up, and in the second generation they re-combine in various ways. Thus, crossbreeding is said to "break the type," and in the reshuffling or segregation of characters which occurs in the second generation we have a number of new types from which to select the plants desired.

That crossbreeding is the most important method of improvement is supported by a study of the returns issued by the Government Statist, showing the areas sown with each variety. This return is compiled from information received direct from farmers, and provides valuable information regarding the varieties grown in each district. This year ten of the most extensively grown varieties

Select-bred, graded seed wheat at the Werribee Research Farm, ready for distribution to farmers.

occupy more than 87 per cent. of the area sown to wheat. Comparing these with the ten leading wheats grown in 1925-26 (only six years back) some very striking facts are revealed. In the first place, we find that Federation has been displaced from the position it held so long at the head of the list, and is now grown to a lesser extent than both Free Gallipoli and Ranee. Secondly, no less than six of the varieties grown in 1925 have been replaced by new wheats which, in the opinion of the farmers, at any rate, are superior to the old. Another outstanding feature indicating the importance of cross-breeding already mentioned, is that all the new varieties which have obtained a place in the first ten are the result of this method of improvement.

The six wheats which have won their way into favour during these few years are—

1. Free Gallipoli
2. Ranee
3. Sepoy
4. Rajah

All bred at the State Research Farm, Werribee.

5. Nizam—Bred at Longerenong Agricultural College.
6. Nabawa—Originally crossed in New South Wales, but final selection made in Western Australia.

These six wheats, with the four surviving old ones, Federation (bred in New South Wales by the late William Farrer), Major, and Currawa (bred at Dookie by Mr. H. Pye), and Penny (a selection from Western Australia), comprise the ten most extensively grown wheats in Victoria this year.

The rapid manner in which the Werribee-bred wheats have come into favour with farmers is indicated by the fact that while they were sown on only 2 per cent. of the total area under wheat in 1925, to-day (only six years later), 2,116,000 acres, representing over 65 per cent. of the total area sown, is under varieties bred at the State Research Farm, Werribee. One variety alone, Free Gallipoli, occupies more than one-third of the total area; Free Gallipoli and Ranee combined cover more than half the area, while these two wheats, with other Werribee varieties, Sepoy, Rajah, Ghurka, and Mogul, comprise practically two-thirds of this season's wheat crop in Victoria. It has been estimated that these new wheats would outyield the varieties they have displaced by at least 2 bushels per acre, and valuing the extra wheat so obtained at only 2s. per bushel, we see that their introduction gives a gain of over £423,000 to the growers, and £73,500 worth of extra freight for our railways.

"Selection" Plots at the Werribee Research Farm.

Tobacco Growing

IV.—Flue-curing Barns.

By W. J. B. McDonald, B.Agr.Sc., Assistant Inspector of Agriculture; and G. E. Coghlan, Tobacco Field Officer.

The first Article of this Series which appeared in the August issue of the Journal dealt with the soil and Climatic conditions most suitable for Tobacco growing and the preparation of Seed beds. Subsequent Articles in the September and October issues described the methods of transplanting the seedlings, and the work involved in the care of crops.

FLUE curing of tobacco is general throughout the tobacco-growing districts of Victoria. This process is the best which has yet been devised for keeping tobacco leaf pure, and ensuring the development of its most valuable characteristics. Indeed, flue-curing enhances the value of the leaf to such an extent that local manufacturers refuse to purchase tobacco that has not been cured in this way. The advantages of flue-curing are—

(*a*) the rapidity with which curing—not merely drying—is effected is greatly increased.

(*b*) Subsequent to harvest, the grower largely is independent of weather conditions.

(*c*) The erection of huge air-drying sheds is not necessary.

(*d*) The grower is enabled to produce a more valuable and uniform product, the control of the colour being largely in the hands of the operator.

The curing of tobacco involves chemical changes within the leaf cell, the manner in which these changes proceed depending on temperature and humidity conditions within the barn. The distinctive feature of the flue method of curing tobacco is that the curing barn is equipped with a system of large pipes through which gases artificially heated to varying temperatures are passed. The gases, of course, do not come in contact with the leaf.

To provide the necessary adjustment of temperature and humidity, a positively controlled ventilating system must be incorporated in the building, that is, the barn must be so constructed that the curer, at will, can make it

A Flue-curing Barn constructed of fibrous cement sheets.

completely air tight or, by altering the ventilators, provide any requisite movement of air. Several types of barn have been designed, individual builders incorporating various modifications with the object of securing better control of temperature and humidity. It is not possible to obtain any unanimity of opinion as to the best type of barn, each recognized style having its advocates. The main difficulty encountered is in ensuring a uniform and sufficient movement of air, or at other times, in holding the barn in an air-tight condition.

The best type of roof is a much-debated point, popular opinion being fairly equally divided between the gable-ended style (fig. 1) and the "hip," or four-sided roof (fig. 10). At the present time the greater favour, possibly, is accorded the gable-ended roof,

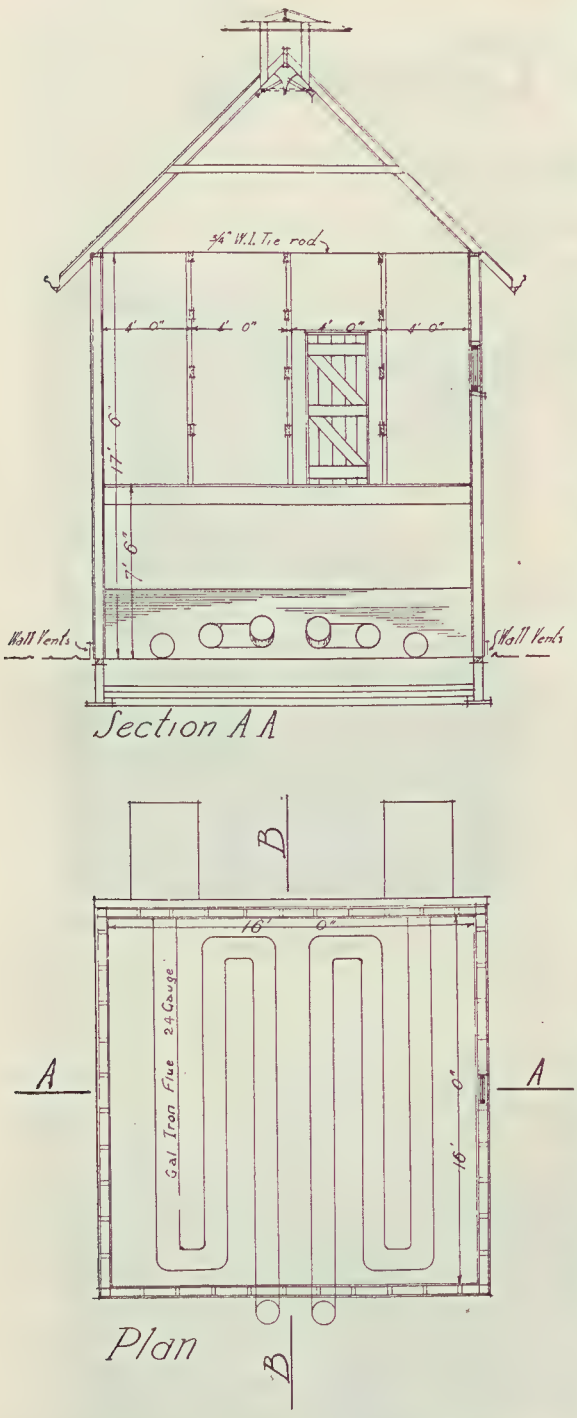


Fig. 1.—Sectional elevation and plan of gable-roofed Barn, showing distribution of flues.

Advantages claimed by its advocates are a greater ease of construction and a more uniform movement of air within the barn.

To maintain a high temperature without too great a consumption of fuel, and to make further provision against air leaks the walls are double lined, the intervening space being filled with chaff, seaweed, earth, or some other insulating material.

Size of Barn.

When determining the size of barn to be built, several factors should be considered. Relatively small barns are more easily and economically handled than large ones, and in general turn out a better sample of leaf. The barn should be of such a size, that from the area of crop matured, and with the labour available, it can be completely filled in one day.

Practice has established a 16 ft. x 16 ft. barn with 17 ft. 6 in. walls as standard size for this State. This is quite a convenient size with which to work, and is capable of holding up to 8 acres of normal crop. The following sizes are suggested as being suited to cater for the areas indicated:—

12 ft. x 12 ft. x 14 ft., to handle 4 to 5 acres.

14 ft. x 14 ft. x 15 ft., to handle 5 to 6 acres.

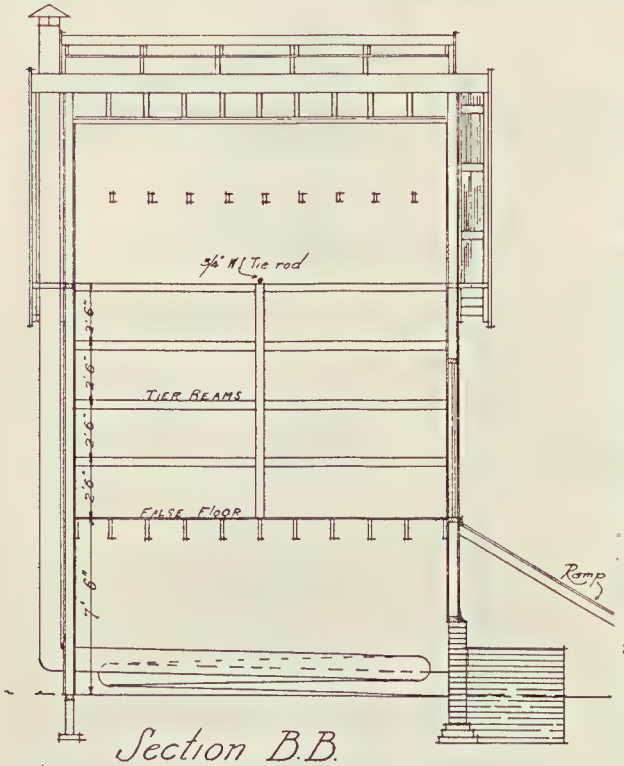
16 ft. x 16 ft. x 17 ft. 6 in., to handle 7 to 8 acres.

If areas larger than 8 acres are being planted, two small barns will be more convenient than one large one.

Choosing the Site.

In handling tobacco leaf, it is advisable from the point of view of both economy and the quality of the cured leaf, to eliminate unnecessary transport. Consequently the barn should be situated in such a position that, as far as possible, it is close to both the tobacco field and the storage shed, but not close enough to the latter to involve it in any fire risk. In this latter connexion it may be pointed out here that it is a wise precaution to insure all tobacco buildings and stored leaf against loss by fire.

The site should be well drained and possessed of a soil that will afford a firm foundation. A gable-ended barn probably is placed most favorably when the direction of the ridge is at right angles to the direction of the prevailing wind.



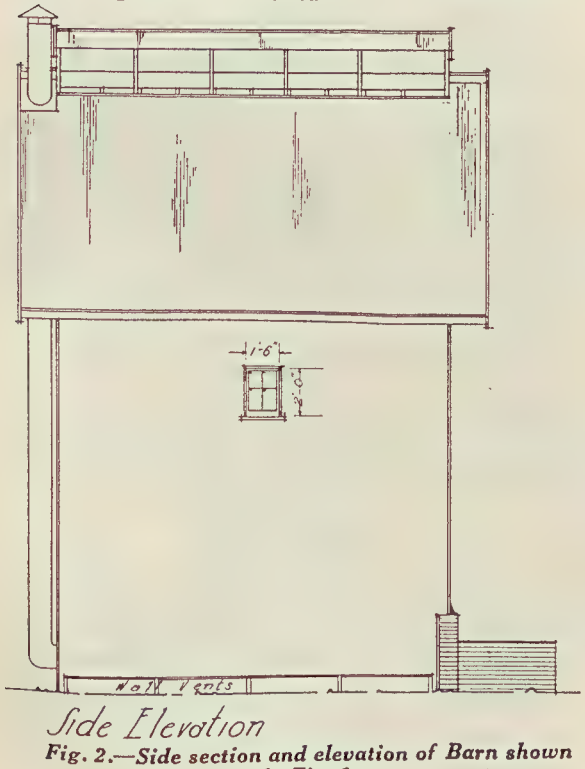


Fig. 2.—Side section and elevation of Barn shown in Fig. 1.

Materials.

Various materials may be used in constructing a flue-curing barn, the choice being a matter for the grower himself. Suitable materials are logs, weatherboards, galvanized iron, and asbestos cement sheets. Galvanized iron is the material most frequently used. Flat iron is cheaper, but not so rigid as the corrugated, and when the former is used it is necessary to construct a slightly more rigid framework than would be needed for the latter. With weatherboards there is greater risk of destruction by fire. Concrete is not regarded as suitable, because of its capacity to absorb an appreciable quantity of water which takes a considerable time to drive out when the drying process is being accomplished. This type of barn also takes much longer to cool down after the fires are drawn.

The accompanying plans illustrate fairly completely the method of constructing either a gable-ended or hip-roof barn, and are intended primarily for the guidance of those readers who have had no previous experience in barn construction. It is anticipated that greater refinements in ventilating and heating systems will be evolved by the ingenuity of Australian growers; in fact, several growers already have experimented along these lines. However, until such time as these refinements have been established as an economic proposition, new growers cannot do better than follow established practice. Readers desiring any amplification of the plans are invited to communicate with the Department of Agriculture.

The Furnace.

It is a generally accepted fact that two heating units are more effective in providing and maintaining a uniform temperature than one; consequently two furnaces are always recommended.

In many cases that section of the wall in which the furnaces are set is bricked to a height of 3 feet as a protection against fire. In all cases the fire box should be adequately insulated, 9 inches of brickwork backed by asbestos sheeting being the minimum protection allowable. The furnaces are built partly below and partly above ground level, provision being made for a fire box 1 ft. 6 in. wide by 2 ft. 9 in. deep by 5 ft. in length.

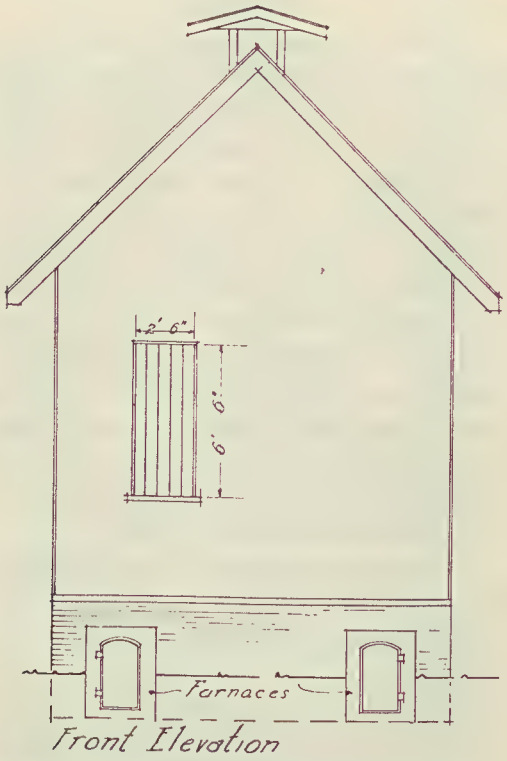


Fig. 3.—Front elevation of Barn shown in Figs. 1 and 2.

Take out the necessary trenches to a depth of 2 feet and build a 9-in. walled-brick furnace, the distance from the bottom of the pit to the underside of the arch being 3 ft. 3 in.

Cast-iron fire bars should be built 6 inches above the bottom of the pit to allow for the accumulation of ashes and provide the necessary draught. Cast-iron doors set on hinges let into the brickwork can be fitted advantageously. Mortar should be mixed, at least

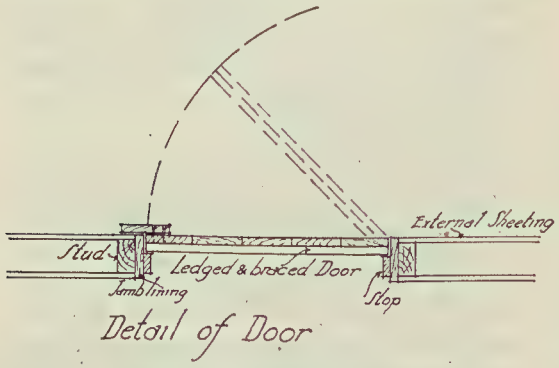


Fig. 4.—Detail of Door.

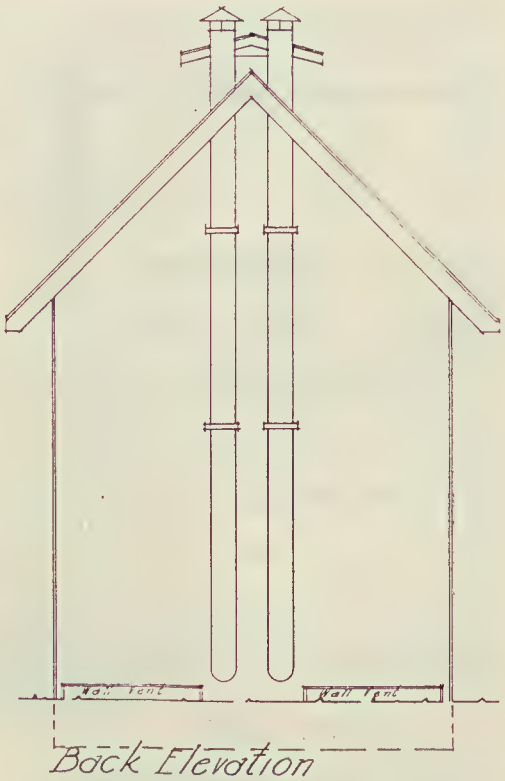


Fig. 5.—Back elevation of Barn shown in Figs. 1 and 2.

one week prior to using, from freshly-burned lump lime mixed with sand in the proportion of 3 to 1. Soil must be rammed firmly round the outside of the furnace, and iron stakes driven well into the earth at the four corners. These should be braced across the top with stout wire to prevent the furnace from cracking when heat is applied. A trench the full width of the furnace should be opened in front of it for a distance of 6 feet. The back of the furnace should sit flush with the wall of the barn, providing at this end for a circular opening sufficiently large to admit an 11-in. flue pipe at ground level.

Flue Piping.

The flue piping is laid down in the manner indicated in Fig. 1, one system coming from each furnace and being placed about 2 feet distant from the walls. Commencing at ground level the flue pipe maintains a gradual rise to the point of exit. The first length of piping should be of heavy material; four-foot lengths of 10-in. cast-iron water piping

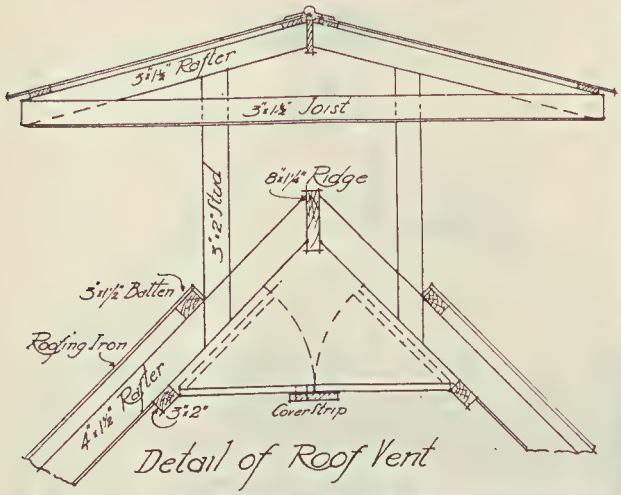


Fig. 6.—Detail of Roof Vent.

are quite suitable; the remaining flues may be constructed of 24-gauge or heavier galvanized iron; these may either be made by the local plumber or purchased made up from various manufacturers. The first length of flue preferably should be flanged, the flange lying flush against the inside wall of the furnace. It is set in with mortar; subsequent joints in the flue system should be as air-tight as possible. About 80 feet of 24-gauge flue piping and two 4-foot lengths of 10-in. cast-iron piping will be required.

The two pipes—one system from each furnace—are taken out of the barn together. At the point of exit, some suitable protection against fire must be provided. If at this point, over an area of 2 ft. 6 in. x 3 ft., the barn is single walled, the air space thus provided prevents risk of fire from contact between the material filling the walls and the hot flue pipe. The joints round the exit pipes should be packed with asbestos to guard against fire and air leaks. The two flues may unite in a single chimney or be carried on as two distinct chimneys, which should project 1 foot above the top of the barn. Dampers to provide for easy regulation of the furnace should be fitted. Where an iron chimney is used, it must be furnished with the necessary support. It can be lashed to the barn at several points with either hoop iron or wire.

In Fig. 10 a more costly but more satisfactory manner of taking out the flues is illustrated. It will be seen that the two pipes unite in a concrete box, the gases being carried upwards by a single chimney.

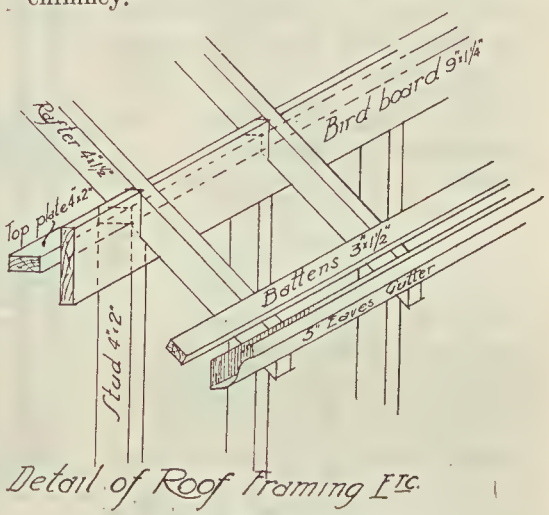


Fig. 8.—Detail of Roof Framing.

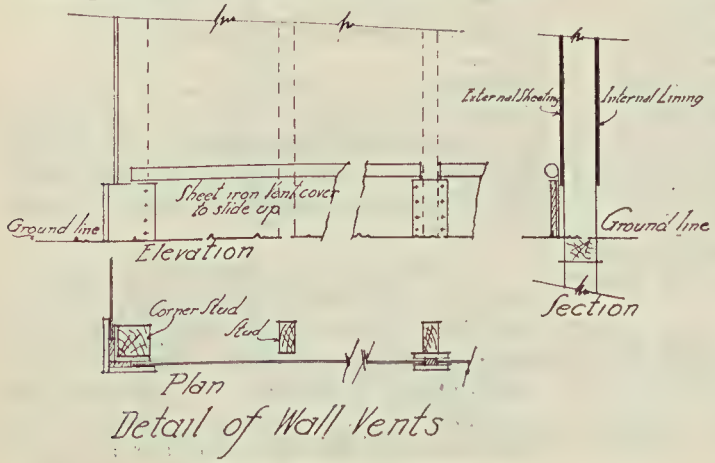


Fig. 7.—Detail of Wall Vents.

Ventilation is intimately associated with roof construction. The most essential factor to be borne in mind is that ventilation must be adequate and perfectly controllable. In a standard-sized barn probably more than 250 gallons of water per cure must be removed by the circulating air. It will be understood readily that a rapid removal of this quantity of water cannot be effected through small ventilators. It is considered that in a barn of this size the area of opening of both the top and bottom ventilators should be at least 16 square feet.

The bottom ventilators are placed just above ground level, and should form a more or less continuous opening round three sides of the barn. In the case of a gable-ended roof, the top ventilator should run the entire length of the ridge. With a "hip" roof it naturally would be built in the centre of the structure. The opening in this case should be at least 4 feet square. All vents must be fitted with effective shutters. The bottom vents provide approximately 48 linear feet of ventilating space, which should be 6 inches in depth. In the barn illustrated these vents are equipped with close-fitting sliding shutters (fig. 7). Hinged shutters are more easily fitted, but are not considered to be so air-tight. Inside the barn deflecting plates to direct the air downward and on to the heated flues are recommended. Any method of preheating the incoming air is a distinct advantage.

The ventilating space at the top of the barn should extend the full length of the ridge, and be at least 1 foot in width. To effect this the roofing is not carried right up to the ridge beam. The opening thus left is protected from the weather by a false roof. This roof should be almost flat, as a steep pitch deflects the air downwards, setting up eddies and circulating currents within the barn. The vent is closed internally by hinged shutters carried on rafters running parallel to the ridge beam. These are controlled by cords running over pulleys. The shutters open upwards. Cross pieces must be fitted at suitable intervals for the purpose of carrying the shutters when they are allowed to fall into the closed position. The method of fitting and constructing is indicated in Fig. 6. To cover the crack between the two shutters, a cover strip should be nailed to one of them.

Particular attention should be paid to the eaves, eliminating, as far as possible, air leaks through this portion of the structure. Details of construction are shown in Fig. 8. Guttering, to carry off rain water, as shown in this illustration, is not essential, but in drier areas the amount of water that could be collected by a curing barn may make its conservation worth while. Doors should be tight fitting. Fig. 4 suggests a suitable method of accomplishing this.

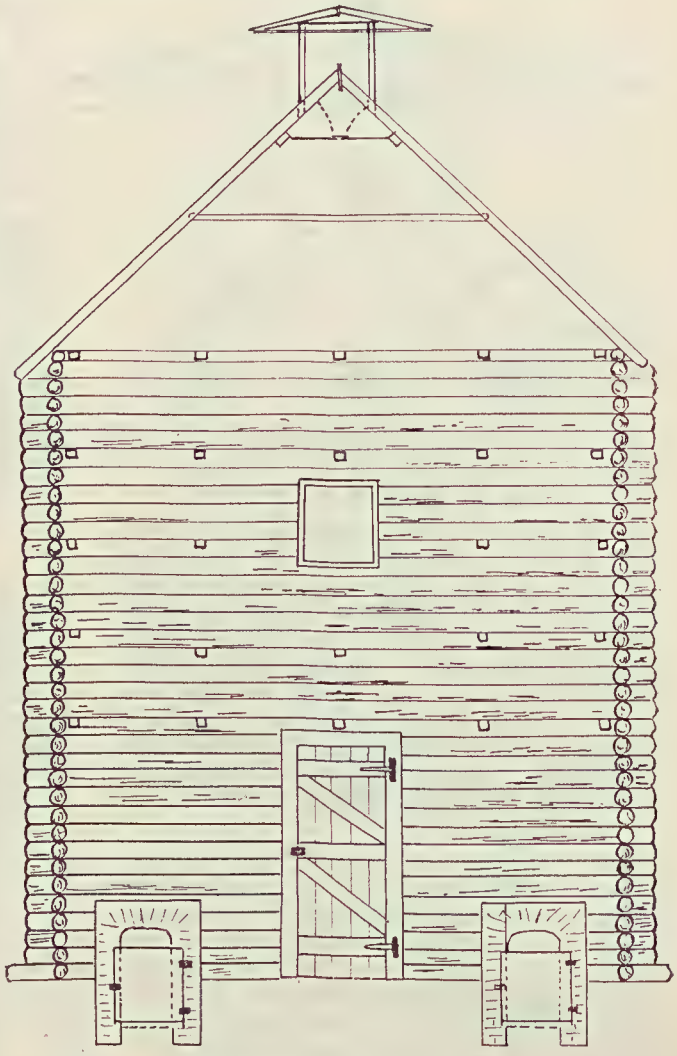


Fig. 9.—Elevation of Log Barn.

The revolving cowl illustrated in Figs. 10 and 11 is an example of an attempted refinement in ventilator construction. This method should eliminate any back pressure or aerial eddies caused by a strong wind blowing across the mouth of the ventilator. The inner and outer covering of the walls are left to the

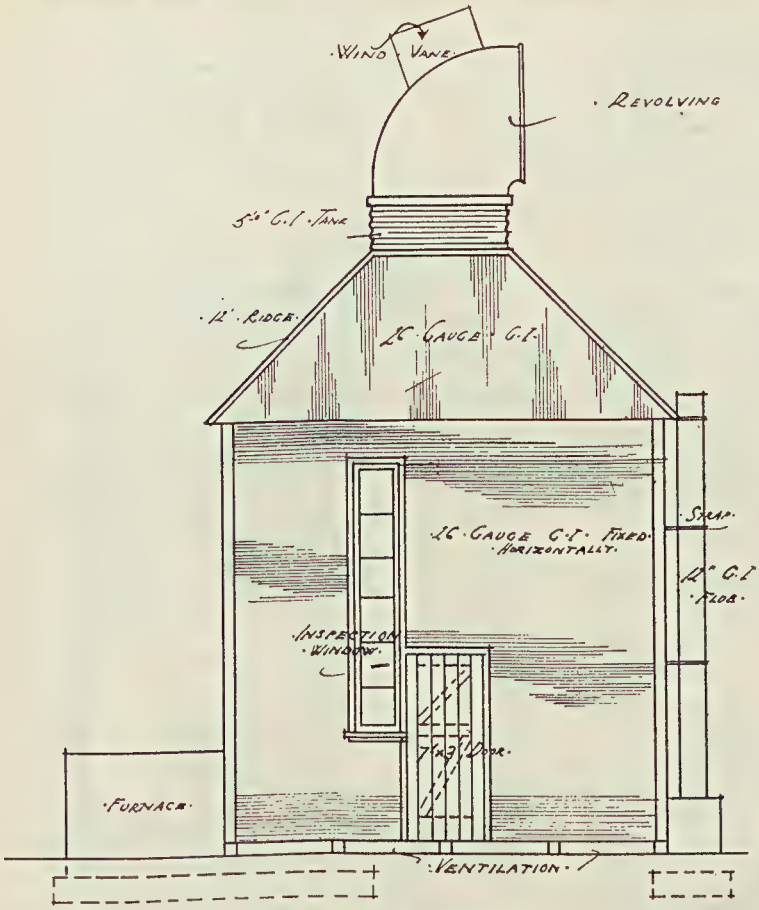


Fig. 10.—Plan and elevation of hip-roofed curing barn.

choice and convenience of the builder. It is considered that the cheapest iron available would do. The intervening space can be filled with any suitable material available. It is wise, however, to leave an air space around the furnace.

The roof should be covered with galvanized corrugated iron with 6-in. end lap and two corrugations side lap, and secured with spring-head nails. It may be lined internally with ruberoid or similar material, which should be carried down over the eaves to make a more air-tight joint. The roof over the ridge pole could be covered with flat iron.

A long narrow window as shown in Fig. 10 allows a more complete inspection of the hanging leaf than is possible through a small one.

The actual disposition of the tier beams (or racks on which the sticks of tobacco are hung) within the barn rests with the individual builder. The first tier, however, should be 7 ft. 6 in. from the floor with 4 feet between beams. Subsequent tiers should be 2 ft. 6 in. apart, or, in districts where the size of leaf is normally rather small, 2 feet apart, the top tier being level with the eaves.

In the gable-ended barn illustrated a floor is shown 2 ft. 6 in. below the first tier beams. The door, naturally, is on the same level, a ramp leading up from ground level. The floor is covered with slats placed just sufficiently close to enable one to walk on it with comfort. This floor,

not by any means a common accessory to existing barns, serves two purposes. It provides a somewhat more uniform movement of air, and greatly facilitates the placing of the sticks on the racks. In the illustration the floor is shown at 7 ft. 6 in. from the ground. This could be better placed at 5 feet, leaving the first tier beams at the 7-ft. 6-in. level. Where this upper floor is not fitted the door is at the ground level.

In this particular barn the tier beams are so arranged that they run in an unbroken series the full length of the barn, and are placed so that a person entering the door walks in between the beams.

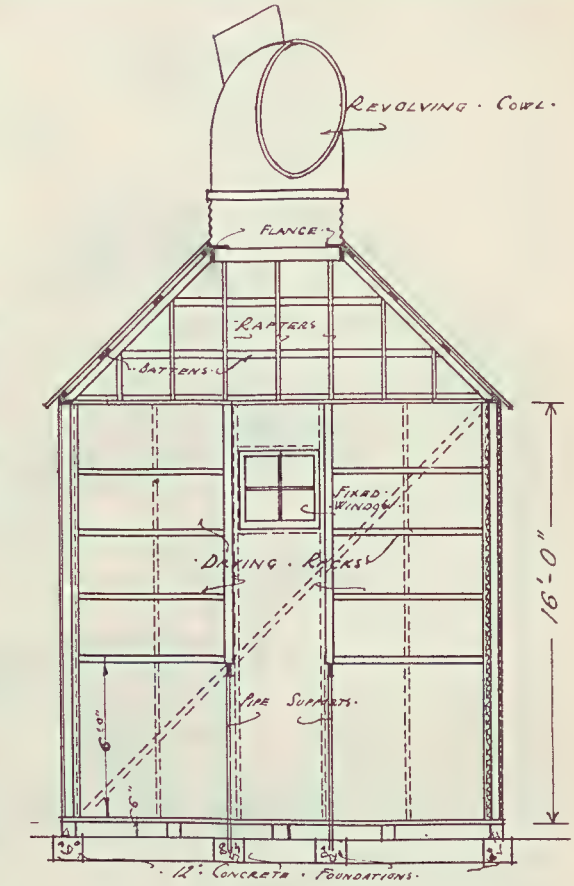
An alternate arrangement of racks is shown in Fig. 11. In this instance the racks run at right angles to the door opening, a corridor dividing them into two sets.

Specifications of Gable-ended Curing Barn.

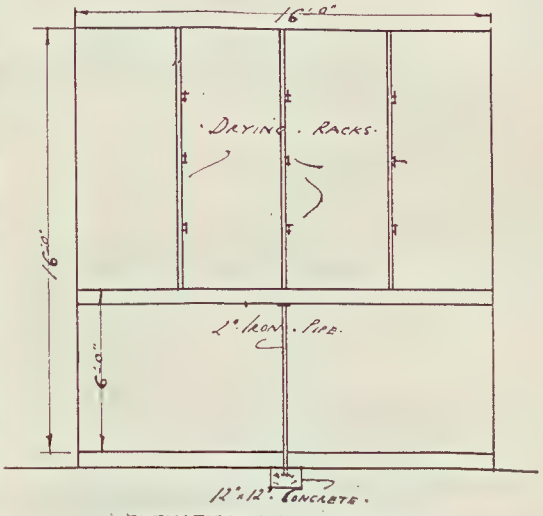
Stumps.—4″ x 4″ jarrah, at 4′ centres, with 9″ x 9″ x 1½″ sole plates.
Bottom Plate.—4″ x 3″.
Studs.—4″ x 2″ hardwood at 18″ centres, 4″ x 4″ at angles.
Top Plate.—4″ x 2″ hardwood, halved at angles.
Struts.—3″ x 1″ hardwood, checked into studs.
Roof Covering.—Galvanized corrugated iron, with 6″ end lap and 2 corrugations side lap, secured with spring head nails.
Roof Vent.—To be constructed with 3″ x 2″ studs, and 3″ x 1½″ rafters and joists.
Hinged vent covers to roof to be constructed of 6″ x ⅞″ T. and G. boards, hinged to 3″ x 2″ battens.
Door to be ledged and braced, constructed of 6″ x ⅞″ T. and G. boards, and hung with tee hinges.
Door Sill.—9″ x 1½″ jarrah.
Ramp to be constructed on 4″ x 3″ bearers, and covered with 3″ x 1″ hardwood battens.

A Log Barn.

In areas where standing timber is readily available, the most economical type of barn is what may be termed a log and mud or wattle and daub barn. A building of this type can be constructed, excluding labour charges, for an expenditure of about £40 to cover cost of roofing iron, fittings, and necessary squared timber. The logs required are as follow:—Eight solid logs not less than 9 inches in diameter at the smaller end, and about 18 feet long, to serve as the base of the structure; from 130 to 140 logs of similar length, as uniform in size as possible, and about 6 inches in diameter, to form the walls; four solid corner posts, 20 tier beams, and a quantity of smaller poles for rafters.



SECTION



ELEVATION OF DRYING RACK

Fig. 11.—Section of hip-roofed curing barn, showing position of drying racks.

Any logs showing signs of piping or hollowness should be discarded. Logs should be cut and barked as early as possible. At least two months should elapse between time of cutting and the erection of the barn. Sappy logs are very difficult to handle.

Corner posts, while not absolutely necessary, serve as a useful guide in maintaining the perpendicular nature of the walls, and later form a convenient frame on which to hang the tier beams. Corner posts 8 inches square at the smaller end should be erected at the four corners of a 16-feet square. These should be 4 feet in the ground, and project 17 ft. 6 in. above ground to the wall plate. The first cross beams should be let into the posts 7 ft. 6 in. above ground level, and as the weight they will have to carry is considerable they should not be less than 5 inches in diameter at the smaller end. On these, poles running the full length of the room are placed 4 feet apart. The arrangement of the tier beams is similar to that shown in Fig. 2.

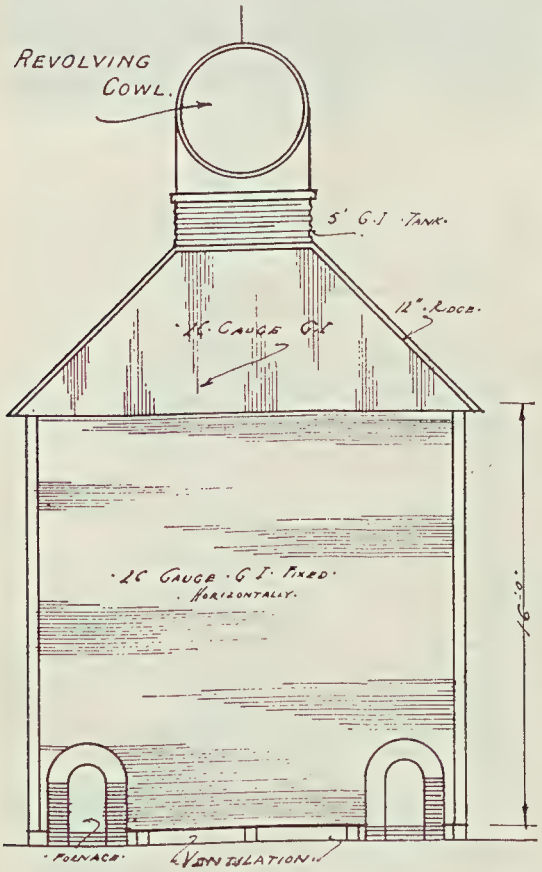


Fig. 12.—Side elevation of hip-roofed curing barn.

In constructing the wall, logs should be notched at each end and interlocked in the normal fashion. The interstices should be filled with mud, the material being well worked into the cracks so that leakage will be prevented. In one wall provision must be made for fitting in two furnaces, one door, and an inspection window. The size of the opening required for the furnace is 3 feet wide by 2 feet deep. A second window should be made at a different level so that as much as possible of the hanging tobacco can be inspected.

The method of construction of the furnaces and the arrangement of the flues have been already indicated.

The roof should have plenty of pitch and, except for the ridge beam, undressed timber may be used. Rafters should be placed 2 ft. apart, centre to centre. The arrangement of the top ventilators is similar to that detailed in Fig. 5.

The roof should be covered on the outside with roofing iron and lined inside with ruberoid sheeting or some similar material which being pliable can be carried down over the eaves to make a more air-tight finish. In a gable-ended structure that portion of the end wall between the eaves and the ridge beam can be covered with weatherboard or iron.

In laying the bed-logs and first covering log, arrangements must be made for provision of the bottom ventilators. This is obtained by cutting three 4-feet lengths out of the bed-log to a depth of 3 inches. The next log fitted should be of similar size to the bed-log, and cut in a corresponding fashion, so that when fitted the gaps cut out of the two logs fall opposite one another, making a series of vents 4 feet x 6 inches in depth.

Acknowledgment.

The writers gratefully acknowledge the assistance given by Mr. Carlton, of the Public Works Department, who prepared the plans and constructional details of the gable-ended barn. They are indebted also to Mr. Allan F. Showers, of the Glenbervie Timber Company, Essendon, for the plans of a "hip roof" barn.

Dairying at Tallangatta

Progressive Farmers

By Geo. Walker, Dairy Supervisor

TALLANGATTA, on the Mitta Mitta River, some 20 miles from its junction with the Murray at the Hume Weir, is the centre of a fertile district at one time chiefly renowned for its fat stock. The town is situated in the valley at the junction of the Tallangatta Creek and the Mitta River, and is surrounded by steep hills used chiefly for the grazing of sheep. The Mitta Valley is over 40 miles long, and is one of the most fertile portions of the district. It is in the Tallangatta Creek Valley, however, that the most noticeable improvement in dairy stock and in quality of pastures, &c., has taken place in recent years.

Mr. D. Nichol's Herd at Tallangatta.

This improvement is due largely to the activities of the Tallangatta Herd Testing Association, whose two units are now testing some 1,800 cows.

The growth of the dairying industry in the Tallangatta district is illustrated by the increase in the output of the Tallangatta Butter Factory and Creamery Company, a co-operative company founded in 1892. The earliest balance-sheets are not available, but in the year ended 30th June, 1906, less than 100 tons of butter was manufactured. In the following year 150 tons was produced, and the average selling price was 11d. per lb. The average price paid to dairy farmers in this season was 4.33d. per lb. for cream and 3½d. per gallon for fresh milk. (The payment on a butter-fat basis calculated on daily test was not introduced until many years later.) For the year ended 30th June, 1930, 418 tons were manufactured and sold for a total of £80,750. The average price paid for butter-fat this year was 18.9d.

The past season was a record one for the company, as it would also appear to have been for the whole State as far as the amount of production is concerned. The output of butter was 569 tons, worth £85,238, and the average price paid to the dairy farmers for choicest butter-fat 14.5d. per lb. Despite the lower value per lb., the increased output due to such a bountiful season has resulted in a greater total return to the producers. When one takes into consideration the fact that the favorable season made it possible to effect a substantial reduction in the quantities of concentrates purchased, it is apparent that the increased production resulting has more than offset the lower market rates for butter-fat.

In Tallangatta, as in all other districts, the measure of success depends on the individual's aptitude for the work, or "dairy sense," as one might describe it. This in many cases is a more important factor than the quality of the soil on which a farm is situated, and one finds men who by hard labour and improved methods of cropping, breeding, and culling, are making a bigger return per £100 of invested capital, and often a bigger return per acre, than are those with farms situated on more fertile areas in the same district.

Some 8 miles from Tallangatta, in the Tallangatta Valley, is the locality known as Cascade, so called from the creek which here leaps down the slopes of Mt. Cudgewa to meet the Tallangatta Creek. Here in close proximity are situated the three respective farms of Messrs. Brown, Nichol, and Pleming.

Mavis Pleming, Ray Pleming, and Doug. Nichol enthusiastic members of the Tallangatta Junior Stock Club.

Mr. D. Nichol's Farm.

Mr. D. Nichol's property consists of 238 acres, of which 107 acres is held on a seven years' lease. There is 150 acres of flat country, and the balance is on the hillside. The freehold property, bought in April, 1915, at £18 per acre, has since doubled in value.

In 1915 only 28 cows were milked; eight years later the number had increased to 40, and now, sixteen years after, it is 60. The foundation herd was of mixed breeding, Shorthorn strain predominating. The average production from this herd for the first year, according to factory returns, was 161 lb. of butter-fat per cow. Mr. Nichol realized that the only reliable way to build up a herd was to breed his own, and so, in 1919, he purchased from J. D. Read, of Springhurst, the herd sire Petain of Springhurst, from Nobelia of Springhurst, by Investigator of Melrose. Following this bull Democrat of Springhurst, from Empress by Arcadia's Choice of Tarnpirr was used.

Of the present grade herd, some nineteen were sired by the former bull and sixteen by the latter. The bull at present in use is Toreador of Springhurst, from Gladiolus of Springhurst, by Starbright's Prince of Glen Iris. Gladiolus produced, under standard test in the 1929-30 period, 600.25 lb. butter-fat, and if her milking quality be transmitted through her son, Mr. Nichol in a little while should have some wonderfully good heifers. It is worthy of note that the first calves sired by this bull are very uniform in appearance and carry the same markings as their sire.

Fodder Crops.

Approximately 30 acres of oats is grown annually. This is grazed through the winter and early spring, and shut off in October for hay-making. From 15 to 17 acres of Japanese millet is usually grown for summer feed. This is sown during October, and eaten off early in January. Under normal summer conditions this crop is sufficient to supplement the pasture for from two to three months. The seed is sown shallowly in a seed-bed broken fine with spring-tooth harrows, followed by rolling to compact the seed-bed. Mr. Nichol finds that early fallowing and the use of 80 to 90 lb. of superphosphate and 20 lb. of seed per acre are essential to success with this crop.

On this farm superphosphate has been applied to the pastures for some five years. In the first year 2 tons was distributed, in the second 6 tons, with 8 tons in each of the third and fourth years, and 4 tons during the past winter months. The average rate of application has been 150 lb. per acre. This top-dressing has resulted in a noticeable increase in the growth of clovers and trefoils, chiefly of the subterranean and medick families.

Of the permanent pasture some 18 acres formerly under cultivation has been sown down with the following mixture:—Perennial rye grass, 15 lb.; alsyke clover, 6 lb. red clover, 2 lb. and cowgrass, 2 lb. per acre. On the higher land *Medicago maculata* or spotted-leaf medick and subterranean and birdsfoot clovers predominate, while on the low-lying flats cocksfoot and rye grasses, White Dutch clover, and several varieties of trefoil thrive.

A set of peg-and-chain grass harrows has been put to good use in the winter months during the past two years in renovating old

Ray Pleming with his Champion Calf.

Mr. J. Hindle's Dairy Herd.

pasture. This working has been followed by a top-dressing with superphosphate at the rate of one bag per acre, approximately 100 acres of the farm being worked in this way each year.

Feeding Methods.

During the winter months it is the practice to feed oaten hay to dry stock in the paddocks, and oaten chaff and bran are fed to the freshly-calved cows in the spring. Pollard also is used when the price warrants, and is found to be economical when fed with bran; it is also a partial preventative of scouring during the early spring. During the dry autumn in 1930 over 20 tons of bran and pollard was fed to the herd, in addition to 4 tons of cotton-seed meal. Mr. Nichol has found the following mixture suitable for feeding to cows while in milk:—Bran, 3 lb.; cotton-seed meal, 2 lb.; and crushed oats, 1 lb. This he considers to be a maximum daily allowance for an average cow in the herd while on natural pasture.

Mr. Nichol depends on the help of his family for almost all labour on the farm. His only son, who is still attending school, is as enthusiastic over the working of the farm as his parents, and is a keen member of the Tallangatta Junior Stock Club. Probably when this young farmer leaves school there will be more legumes grown, and consequently less concentrates required to feed the herd.

Herd Testing.

Mr. Nichol, who was a foundation member of the Tallangatta District Herd Testing Association, is still one of its staunchest advocates. Like other enthusiasts, he cannot understand the man who, even after seeing a practical illustration, perhaps on his neighbour's farm, of what may be effected in the way of herd improvement by its aid, does not follow suit. In the first complete testing year (1926-27) Mr. Nichol's herd averaged 196 lb. of fat. This was followed by average yields of 305, 345, and 301 lb. per cow in the succeeding years. These figures do not include allowances for junior heifers. In explanation of the falling away for the year 1929-30, it may be pointed out that besides nine heifers, three of which were junior two-year-olds, there were also included in the herd nine mature cows which suffered the after effects of milk fever in the spring months. Pearl, a grade Jersey, which produced 414 lb. of fat at three years of age, and 520 lb. in the following year, produced in the season just passed 617 lb. of butter-fat. For the year ending 30th June, 1931, 49 cows, including 41 mature cows, five three-year-olds, and three junior two-year-old heifers, averaged, with allowances for heifers, 367.48 lb. of butter-fat. It should be remembered that these results were produced under north-eastern climatic conditions, which are not quite so favorable as our best dairying parts, and also that the herd is machine-milked.

Stock.

All calves are dehorned with the aid of a caustic-potash pencil. The method employed is to clip the hair surrounding the horn buds, smear the area surrounding the bud with vaseline, dampen the horn bud, and apply the caustic stick. Calves should be so treated early—certainly before they are a month old; if carried out properly, few failures result, and it is seldom that a second application of the caustic-potash is required. Mr. Nichol recently purchased two registered Jersey heifers, Milkmaid of Banyule and Noble Guitar of Banyule, as a foundation for a pure-bred Jersey herd. As a result of the breeding from record-bred bulls a ready sale for young stock is found. In 1930 thirteen yearling heifers were sold at £6 10s. per head.

Pig-raising, though not so profitable now as it was a few years since, is a branch which cannot be overlooked on the average dairy farm. In the 1929-30 season Mr. Nichol disposed of 94 baconers which were bred on the farm. For this purpose a number of Middle York brood sows are kept and mated to a Large York boar bred by Mr. T. Harvey, of

Boisdale. Their progeny are quick growers, and can be disposed of when five months old as light baconers weighing from 110-120 lb. carcass weight. In fattening, skim milk supplemented by pollard and soaked barley is used. This method of using barley, however, is found to be rather wasteful, and would be improved upon by first gristing the grain.

Other Farms.

On an adjoining farm, that of Mr. L. V. Brown, which is 280 acres in area, some 50 grade Jerseys are milked. The land is similar to that of Mr. Nichol's, the flats being covered with a layer of silt-deposit over about a foot of rich black soil, which in turn covers a layer of decomposed vegetable matter and granite-sand—probably an old swamp.

A silage pit on this farm contains approximately 30 tons of maize ensilage, which has been underground for several years, and is apparently still in a good state of preservation. Mr. Brown has pinned his faith to the Duroc-Jersey breed of pigs, and receipts for sales have amounted to as much as £400 in a season. In the 1929-30 season those sold brought a total of £205; they were reared and fattened partly with skimmed milk, and during the same season 33 heifer calves also were fed on skimmed milk. Seven acres of artichokes were planted some years ago for pig feed during the winter months. This crop is now self-sown annually and harvested by the pigs. An occasional cultivation only is necessary.

On Mr. Pleming's farm, which is situated on higher ground than either of the farms already mentioned, similar practices for pasture and herd improvement have been carried out. Twenty-eight milking cows are run on an area of 205 acres, portion of which has been devoted to sheep grazing. Mr. Pleming believes that it would be more profitable to devote the whole of his farm to dairying, and has decided to increase his herd and install a milking plant. Since its inception, Mr. Pleming has been a keen supporter of the Tallangatta Herd Testing Association, of which body he is president. He has taken a keen interest in the Junior Stock Club movement, of which three of his children are members. In the 1930 display of the local club, Ray Pleming with his Jersey calf scored first place with 96 points, while in the 1931 display Marjorie was first, her calf "Ruby", scoring 93 points; on this occasion Douglas Nichol and his sister Lesley tied for second place, their exhibits each scoring 92 points.

A striking illustration of value of superphosphate on this country is provided by the experience of Mr. J. Hindle, whose farm of 156 acres is situated on the Hindleton Creek. On this property, which consists of some 40 acres of small creek flats with black alluvial soil and the balance higher or "forest" soil, 5 tons of superphosphates are applied annually. The higher country, which, prior to the use of superphosphate, was sparsely covered with tufts of kangaroo grass, now carries a good sole of subterranean and other clovers. On the flats perennial rye grass, cocksfoot, White Dutch clover, and trefoils predominate.

The production record of the herds of Messrs. Nichol, Brown, Pleming, and Hindle for the year ending 30th June, 1931, is shown in the accompanying table supplied by the Tallangatta District Herd Testing Association.

Owner.	Number Mature Cows.	Number 3-year-old Heifers.	Number Senior 2-year-old Heifers.	Number Junior 2-year-old Heifers.	Average Milk.	Average Test.	Average Butter-fat.	Average Butter-fat (with Allowances for Heifers).
					lb.	%	lb.	lb.
W. Pleming ..	16	9	1	0	7,712	4·42	383	402
D. J. Nichol ..	41	5	0	3	7,264	4.92	357	367
J. Hindle	16	6	1	5	6,492	5.03	327	346
L. V. Brown ..	15	19	8	6	5,854	5.05	295	331

Codling Moth Control

Experiments at Harcourt

By R. T. M. Pescott, M.Agr.Sc., Entomologist.

THE Codling Moth (*Cydia pomonella*) has been much in evidence in the Northern Districts of Victoria in the season just past. Owing to the abnormal conditions existing during the season early varieties of apples were not badly attacked by the Codling, but the warm weather later in the season liberated a large number of moths, with the result that later varieties suffered more severely.

The experiments referred to in this report were carried out on the property of Mr. Thomas Code, at Harcourt. Owing to the failure, through frost, of the apple crop the previous season, a good blossoming and setting of fruit occurred over the greater part of the orchard. Several varieties, particularly Munro, set a light crop. The blame for this was ascribed to Thrips, but actually it was due to the lack of a suitable pollenising agent. The amount of Codling Moth in the orchard was certainly up to that of other years, and, owing to the inclement weather preventing a spraying in early March, the later varieties were more heavily infected than would have been the case had this spray been applied.

The experimental work this season was divided into three main sections—

(*a*) Spraying experiments with various combinations of sprays in an endeavour to determine a more efficient and economic spray programme than that used at the present time.

(*b*) Life history studies in the field by means of lures of various materials placed in the trees. This section was used as an adjunct to (*a*) in that the time of the application of the sprays was determined to a large extent by the numbers of insects caught in the lures.

(*c*) The effect of the standard spray materials on the size and quality of fruit so sprayed.

Codling Moths (five times actual size).

Spraying Experiments.

The primary object in spraying experiments for Codling Moth control is to develop a spray programme which will be effective in reducing the percentage of damaged fruit to a minimum, at the same time reducing the amount of arsenate of lead remaining as spray residue to the limits allowed by law. The particular spray programme must, also, of course, be economically sound.

For the purpose of the spraying experiments, a block of apple trees of mixed varieties and about 100 in number was used. These trees ranged from 20 to 50 years of age, and contained many varieties not now commercially used. However, the majority of the present varieties were included in the experimental block. The spray programmes used are shown in Table I.

TABLE I.—SPRAY PROGRAMMES.

Spray No.	Material.	Dates of Application.
	Block A.	
1 to 5 ..	Arsenate of lead 5 lb. paste to 80 gls. water	23.10.30, 3.11.30, 1.12.30, 5.1.31, and 7.2.31
	Block B.	
1 and 2 ..	Arsenate of lead 5 lb. paste to 80 gls. water	23.10.30 and 3.11.30
3 to 5 ..	White oil emulsion 1 in 40 ..	1.12.30, 5.1.31, and 7.2.31
	Block C.	
1 and 2 ..	Arsenate of lead 5 lb. paste to 80 gls. water	23.10.30 and 3.11.30
3 ..	White oil emulsion 1 in 40 ..	1.12.31
4 ..	Arsenate of lead 5 lb. paste to 80 gls. water	5.1.31
5 ..	White oil emulsion 1 in 40 ..	7.2.31
	Block D.	
1 and 2 ..	Arsenate of lead 5 lb. paste to 80 gls. water	23.10.30 and 3.11.30
3 to 5 ..	White oil emulsion 1 in 60 ..	1.12.30, 5.1.31, and 7.2.31
	Block E.	
1 ..	Arsenate of lead 2½ lb. paste to 80 gls. water	23.10.30
2 to 5 ..	White oil emulsion ¾ gln. to 80 gls. water	3.11.30, 1.12.30, 5.1.31, and 7.2.31
	Block F.	
1 to 5 ..	Arsenate of lead 5 lb. paste to 80 gls. water and spreader ½ lb. per 80 gls.	23.10.30, 3.11.30, 1.12.30, 5.1.31, and 7.2.31

In the above programmes all the sprays were applied with an ordinary motor spray pump with spray gun attachment at a pressure of about 250 lb. per square inch.

The first or calyx spray was applied when the petals were fallen from the majority of the blossoms, and the second spray ten days later. The times of the remaining sprays were determined mainly by the use of lures placed in the trees. Both fermented apple juice and vinegar solution were used for this determination.

In computing the results, all percentages were determined from the actual count of all apples on each tree of an experimental block. All windfalls were carefully examined, and the number of these affected with Codling determined. No distinction was made in tabulating the results between apples showing one, two, or more entrances, nor between fruit with entrances and stings, providing the latter caused a blemish rendering the fruit unfit for export. The bulk of the counting of the fruit was done by the writer; only in special cases when the fruit was urgently required was this not done. In these cases, only the clean fruit was counted by the orchardist, the determination of the Codling apples being left to the writer.

A rough preliminary estimate was made on the 12th January to determine the percentage of infection at that period. By means of records obtained from the bandages of the trees at that time, it was found that the grubs hibernating there were in the larval and pupal stage, so that any infection prior to that period would be the result of the first brood of moths. Table II. gives the complete results of the spraying experiments for the season just completed.

TABLE II.—RESULTS OF SPRAYING EXPERIMENTS.

Block.	Material.	Codling on 15.1.1931.	Codling at Picking Time.
		%	%
A	Arsenate of lead alone ..	6·2	16·7
B	Lead followed by white oil 1–40	2·3	6·2
C	Lead and white oil alternately	3·9	11·3
D	Lead followed by white oil 1–60	1·1	6·2
E	Lead plus oil	4·1	9·4
F	Lead plus spreader ..	4·1	10·7

These results again bear out the conclusions derived from previous Codling Moth experiments at Harcourt, namely:—

(1) Arsenate of lead alone fails to give a satisfactory control.

(2) Arsenate of lead calyx sprays followed by white oil emulsion sprays gave a marked increase in control over other sprays. The same measure of control was obtained when the white oils were used at a strength of 1 in 60 as when they were used at 1 in 40. Owing to this being the first season in which a 1 in 60 strength was used, no definite conclusion can be drawn. The "arsenate of lead and white oil alternately" programme, while a little better than the "arsenate alone" spray, did not uphold the

promise it showed the previous year. The arsenate of lead and white oil spray was also superior to the arsenate alone spray.

Spraying Costs.

The efficiency of a spray programme must not be gauged only on the percentage of clean fruit at picking time, but also by whether the extra fruit obtained more than balances the extra cost due to the materials in the new programme. In this connexion, a comparison will be made between spray programmes A, B, C, D, and E.

As a basis on which to work, it is necessary to assume that one barrel of spray (80 gallons) is sufficient to spray 100 cases of fruit. The cost of arsenate of lead paste is 8d. per lb., whilst white oils are approximately 7s. per gallon. The value of the apples has been taken at 5s. per case. The comparisons are shown in Table III.

TABLE III.—ANALYSIS OF SPRAYING COSTS, ETC.

Spray Programme.	Arsenate Sprays.	Oil Sprays.	Total Cost.	Extra Cost over Programme A.	Extra Fruit per 100 Cases over Programme A.	Value of Fruit.	Overall Profit.
	s. d.	*s. d.*	*s. d.*	*s. d.*		*s. d.*	*s. d.*
A	5 at 3 4 = 16 8 ..	.. .. ..	16 8	..	..	..	..
B	2 at 3 4 = 6 8 ..	3 at 14 0 = 42 0 ..	48 8	32 0	10·5	52 6	20 6
C	3 at 3 4 = 10 0 ..	2 at 14 0 = 28 0 ..	38 0	21 4	5·4	27 0	5 8
D	2 at 3 4 = 6 8 ..	3 at 9 4 = 28 0 ..	34 8	18 0	10·5	52 6	34 6
E	5 at 1 8 = 8 4 ..	5 at 5 3 = 26 3 ..	34 7	17 11	7·3	36 6	18 7

A Good Type of Bandage fixed with a Single Nail.

From the figures in Table III. it will be seen that all the spray programmes used in the experiments were economically sound, whilst the programmes in which the white oils were used at a strength of 1 in 60 showed the greatest margin of profit. Incidentally, this programme has the added advantage of being a scalicide, controlling San Jose and Apple Mussell Scales in the orchard.

Arsenical Residues.

Owing to the possible danger to human life caused by traces of arsenic remaining on apples after spraying, a limit is placed on the amount of arsenic allowable on fruit. This is fixed by law at .01 grain of arsenic per lb. of fruit, the arsenic to be estimated as arsenic trioxide (As_2O_3).

Representative samples of apples from each section of the experimental block were submitted to the Agricultural Research Chemist, the results of whose analyses are shown in Table IV.

TABLE IV.—RESULTS OF ANALYSES.

Spray Programme.	Quantities in grains per lb. of Fruit.	
	As.	As_2O_3.
A	·024	·032
B	·0017	·0022
C	·011	·015
D	·0026	·0034
E	·016	·021
F	·022	·029

An analysis of these figures shows that only two of the spray programmes, viz., those in which oils were used on their own after lead calyx sprays, conformed to the limits required by law. However, as it was the custom of the owner of the experimental block to hand-wipe all apples leaving the orchard, it is possible that all these would conform to the standard when exposed for sale.

Life History Studies.

Life history studies were undertaken primarily with the idea of determining accurately when the moths were actually flying in the orchard, and thus determining accurately the correct time to apply sprays. It was thus found necessary to use lures of various materials hung in the trees. Three materials were used, viz., fermented apple juice, 10 per cent. vinegar solution, and Clensel (a trade preparation which is used extensively in some parts as a lure for fruit fly). These three materials were used for about two months, at the end of which time the fermented apple juice was found to be most satisfactory, and the experiment was continued using this material only. Clensel, as a lure for Codling Moths, was found to be most unsatisfactory, not a single moth, over the period of the experiment, in which ten individual lures of Clensel were used, being captured. However, an extremely large number of flies of all descriptions was captured, thus confirming the experience of other States in regard to this lure.

Regular counts were made of the number of moths trapped in the lure of fermented apple juice. These counts are set out in Table V., and graphically in Fig. 1.

Type of Breeding Cage used in Codling Moth Experiments at Harcourt.

TABLE V.—NUMBER OF MOTHS CAUGHT IN LURES IN ORCHARD.

(6 lures of apple juice used.)

Week Ending—	No. of Moths.
October 11th ..	..
18th ..	1
25th ..	3
November 1st ..	40
8th ..	44
15th ..	40
22nd ..	30
29th ..	20
December 6th ..	14
13th ..	2
20th ..	2
27th ..	5
January 3rd ..	14
10th ..	16
17th ..	24
24th ..	30
31st ..	34
February 7th ..	27
14th ..	16
21st ..	10
28th ..	4
March 7th ..	3
14th ..	10
21st ..	16
28th ..	12
April 4th ..	8
11th ..	2
18th ..	..
25th ..	..

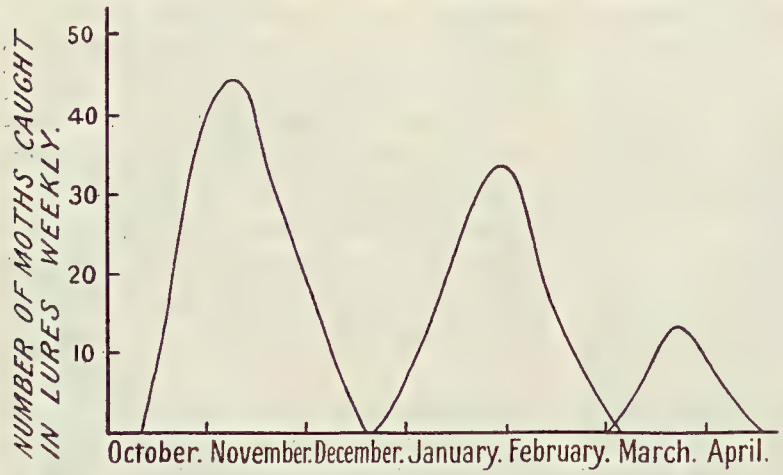


Fig. 1.—Graph showing number of Codling Moths caught in Lures Weekly.

The graph shows the presence of three distinct broods of moths in the year 1930-31, there being two complete broods and a partial third brood. The maximum peaks of each brood were approximately as follows:—

1st brood .. 8th November, 1930.
2nd brood .. 31st January, 1931.
3rd brood .. 21st March, 1931.

Spray Influence on Size and Quality of Fruits.

For several years complaints have been received at the Science Branch that oil sprays have adversely affected the size and quality of fruit, when compared with fruit sprayed with arsenic sprays.

A particularly suitable block of trees was available at Harcourt where this particular problem could be studied, consequently these studies were included in the year's experiments. The block in question consisted of Jonathan apple trees, all of the same age—actually they were all planted on the same day and had received uniform treatment as regards cultivation, spraying, watering, and pruning for at least eight years. To outward appearance the trees were uniform in size and vigour, and presented an ideal block for the experiment.

Three types of spray treatment were carried out, viz.:—

A. Arsenate of lead alone, 5 lb. to 80 gallons of water—five sprays.

B. Arsenate of lead (5 lb. in 80 gallons of water) as the two calyx sprays, followed by three white oil sprays at a strength of 1 in 60.

C. Arsenate of lead (5 in 80) as the two calyx sprays, followed by arsenate of lead (2 in 80) plus white oil emulsion ($\frac{3}{4}$ in 80) —three sprays

The system of layout of these plots was a 3 x 3 Latin square, the actual plan being as shown in Fig. 2.

The five sprays were applied to this block on the following dates:—23rd October, 1930; 4th November, 1930; 2nd December, 1930; 7th January, 1931; and 7th March, 1931.

At harvest time, the produce from every tree was examined carefully and classified according to size into 3-in. and over, $2\frac{3}{4}$-in., $2\frac{1}{2}$-in., and $2\frac{1}{4}$-in. and under fruit. The percentages of each size are shown in Table VI., with a summary of figures in Table VII.

1 12 **A** 2 11	13 24 **C** 14 23	25 36 **B** 26 35
3 10 **B** 4 9	15 22 **A** 16 21	27 34 **C** 28 33
5 8 **C** 6 7	17 20 **B** 18 19	29 32 **A** 30 31

Fig. 2.—Layout of Plots. Each block, as represented by A, B and C, contained four trees numbered as shown in the figure.

TABLE VI.—SHOWING PERCENTAGES OF GRADED FRUITS FOR INDIVIDUAL TREES—HARCOURT, 1930-31.

Tree No.	3″ Fruit.	2¾″ Fruit.	2½″ Fruit.	2¼″ Fruit.
1	Not in experiment			
2	6·6	69·9	21·1	2·4
3	10·2	64·6	22·3	2·9
4	23·4	55·2	16·5	4 9
5	26·6	61·5	11·9	..
6	16·7	52·8	26·0	4·5
7	6·8	81·5	11·7	..
8	8·7	77·6	13·6	..
9	18·5	65·6	11·9	4·0
10	22·4	66·4	7·0	4·2
11	11·1	73·9	15·0	..
12	Not in experiment			
13	2·4	83·8	13·8	..
14	9·0	82·0	9·0	..
15	24·0	70·7	5·3	..
16	14·6	73·6	11·8	..
17	12·4	81·4	6·2	..
18	3·2	77·8	19·0	..
19	4·5	74·7	18·0	2·8
20	11·8	83·1	5·1	..
21	15·0	77·9	7·1	..
22	20·9	76·1	3·0	..
23	28·0	69·1	2·8	..
24	7·6	85·9	6·0	0·5
25	3·3	81·0	14·0	1·7
26	11·6	84·9	3·5	..
27	14·0	77·8	7·0	1·2
28	5·0	71·1	20·5	3·4
29	14·6	76·8	4·0	4·6
30	0·5	34·7	36·1	28·7
31	14·6	70·1	11·2	4·1
32	12·1	68·4	14·1	5·4
33	16·7	81·4	1·9	..
34	20·7	71·9	4·4	3·0
35	11·6	82·6	4·3	1·5
36	11·4	77·1	6·6	4·9

TABLE VII.—SUMMARY.

Percent. Fruit in Size Class.	Treatment A.	Treatment B.	Treatment C.	Mean.	Standard. Error.	S.E. Mean.
3″ fruit ..	12·6	12·0	13·5	12·7	2·19	17·3
2¾″ ,, ..	69·7	74·5	74·7	73·0	4·05	5·6
2½″ ,, ..	13·7	11·5	10·6	11·9	1·58	13·3
2¼″ ,, ..	4·0	2·0	1·2	2·4	2·10	87·0

These figures were submitted to Messrs. Forster and Vasey, Werribee, for their examination. They reported that none of the spraying treatments had had any effect on the percentage of fruit in the various size classes, as not one of the differences recorded was significant.

A thorough examination of the colour of the fruit in the different treatments showed a decided advantage in colour in favour of the oil-sprayed trees. This must not, of course, be given a wide interpretation, but under the condition of the experiments at Harcourt the above results are true.

Summary.

The results of the experimental work at Harcourt this season again showed that satisfactory control of the Codling Moth could not be obtained by the use of arsenate of lead alone. Satisfactory control was obtained where a white oil emulsion was used as an ovicidal spray following the preliminary arsenical calyx sprays, and, moreover, the use of these oil sprays has been shown to be economically sound.

A summary for the seasons 1927-31 is as follows:—

Arsenate of lead sprays alone	26.7 %
Arsenate of lead calyx sprays followed by white oil ovicidal sprays (1 in 40)	8.3 %

The spray programme in which the strength of white oil was reduced from 1-40 to 1-60 gave a similar degree of control to that programme in which a strength of 1 in 40 was used. This bears out results obtained by other observers.

At Harcourt no significant differences were found in the sizes of fruit sprayed with oil sprays when compared with those fruits sprayed with arsenic sprays. The colour of fruit was in favour of the white oils.

Recommendation.

The following spray programme for districts similar to Harcourt can be recommended:—

Two sprays of arsenate of lead (5 lb. of paste lead in 80 gallons of water) as calyx sprays applied at intervals of ten days, followed by three or four sprays (depending on weather conditions) of a white oil emulsion (1 in 40) at intervals of approximately one month. The timing of these latter sprays should be accurately determined by the orchardist himself by the use of lures placed in the trees of his orchard.

Potato Experiments

Results of Tests, 1930-31

By J. T. Ramsay, Potato Expert.

Illowa.

THE results obtained at Illowa for 1930-31 are easily the best secured during the three years the trials have been carried out there. The season in this district was exceptionally favorable, a fact reflected in the heavy yields recorded.

The variety used was Late Carman, and planting was done on 19th and 20th August, 1930, under favorable weather conditions, and with the soil in good order. For the previous two seasons the paddock had been cropped with oats for hay. The plots are conducted on the farm of Messrs. Sheen Brothers. The soil is a dark-red volcanic loam, and as will be seen from the following analysis is very rich naturally.

ANALYSIS—ILLOWA SOIL.

Nitrogen	..	392 parts per 100,000
Phosphoric acid		275 „ „ „
Potash	..	362 „ „ „

Table 1 shows the returns for the season 1930-31, including the yields per acre from the various manurial treatments, the increases from these over the unmanured check plots, cost of manures, cost per ton increase, improved value per acre, and the percentage of the increases.

A good crop of Late Carmans.

A feature of the results is the continued superiority of the super. and ammonium combination, the dressing of 3 cwt. of super. plus 1 cwt. sulphate of ammonia per acre giving a yield of 16 tons 12 cwt. compared with 12 tons 1 cwt. on the "no manure" plot. Although all of the manures gave increased yields, there is a considerable range in the percentage of these increases, the variation for the season being from 5 per cent. to 37 per cent.

TABLE 1.—MANURIAL TESTS, ILLOWA, 1930-31.

Manures per Acre.	Market Tubers.	Increase from Manures.	Cost of Manures per Acre.	Cost per Ton Increase.	Increased Value per Acre.	Net Increased Value per Acre.	Percentage Increase.
	T. C. Q.	T. C. Q.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	%
2 cwt. super.	14 9 1	2 8 1	0 9 6	0 4 0	12 1 3	11 17 3	20
3 cwt. super.	15 0 0	2 19 0	0 14 3	0 4 11	14 15 0	14 10 1	25
4 cwt. super.	15 5 1	3 4 1	0 19 0	0 5 10	16 1 3	15 15 5	26
No manure	12 1 0	..	..	..	..	..	..
3 cwt. super. + 1 cwt. sulph. ammon.	16 12 0	4 11 0	1 7 0	0 6 3	22 15 0	22 8 9	37
3 cwt. super. + 1 cwt. pot. sulph. + 1 cwt. sulph. ammon. ..	15 5 1	3 4 1	2 1 6	0 12 11	16 1 3	15 8 4	26
3 cwt. market garden	14 1 1	2 0 1	1 5 6	0 12 9	10 1 3	9 8 6	16
3 cwt. basic phosphate ..	12 11 3	0 10 3	0 16 6	1 10 0	2 13 9	1 3 9	5

Returns calculated at £5 per ton.

It should be noted also that, where sulphate of potash was added to the super. and ammonium combination, a marked depression of the yield took place, the crop being reduced by no less than 32 per cent. as compared with the super. and ammonium combination by itself. It is interesting, too, to find that the optimum rate of application of superphosphate is reached at about 3 cwt. per acre. Indeed, considering the inherent richness of this soil, it is surprising that a response to manures is shown at all. Only the market size tubers—i.e., table size—were taken into consideration in the weights per acre shown in the tables. Had the small potatoes also been calculated the results from the various manures would show still wider differences.

TABLE 2.—AVERAGE YIELDS, THREE YEARS, 1928-29 TO 1930-31.

Manures per Acre.	Average Yield.	Percentage Increase over No Manure.
	T. C. Q.	Per cent.
Super. 2 cwt.	8 6 2	30
Super. 3 cwt.	8 15 1	36
Super. 4 cwt.	8 15 1	36
No Manure	6 8 0	—
Super. 3 cwt. and Ammon. Sulph. 1 cwt.	9 7 1	47
Super. 3 cwt. and Ammon. Sulph. 1 cwt.	10 11 0	33
Super. 3 cwt. and Ammon. Sulph. 1 cwt. + Pot. Sulph. 1 cwt.	7 19 0	24
Market Garden 3 cwt. ..	7 2 1	11
Basic Phosp. 3 cwt, ...		

Table 2 shows the average yields recorded over the three years of the test and the percentage increases over the unmanured plot. In the case of plot 7 and 8, these manurial dressings have been employed for two years only, and the averages of these have been calculated on that period. This table shows at a glance the superiority of the super. and ammonium combination during the three years under review. While a marked improvement in yield follows applications of super. shows decidedly and profitably from 2 cwt. to 3 cwt. per acre, further advantage is not gained by increasing the rate to 4 cwt. per acre. Individual seasons may show a benefit, but the average over a period of years is the only reliable guide. The application of 3 cwt. super. and 1 cwt. ammonium sulphate is easily the best so far, showing as it does, an average increase of no less than 47 per cent. Again, the potash application shows to disadvantage by reducing the yield over the three-years' period by almost 30 per cent. as compared with the "3 and 1" dressing.

Fish Creek.

The plots at Fish Creek, which are conducted on the farm of Mr. R. Skinner, were planted on 14th October, 1930, on land which had been under grass for six years. The variety used was Carman 3. The soil is a grey clay loam typical of much of the soil of the district.

Unfortunately, the tops of the plants were badly damaged early in December by an attack of Irish blight from which they did not recover subsequently. After the blight attack in December the weather improved and, so far, checked blight development that practically none of the tubers was affected, although the yield was severely reduced.

The yields for the 1930-31 season are given in Table 3, but, in reading this table, it should be remembered that the manures had no real chance of functioning properly. One effect of this was a very large proportion of small tubers amounting in most cases to over 30 per cent.

TABLE 3.—POTATO MANURIAL TRIALS, FISH CREEK.

Manures per Acre.	Yield, 1930-31.
	T. C. Q.
3 cwt. super.	2 7 2
6 cwt. super.	2 10 0
9 cwt. super.	2 12 2
6 cwt. super + 1 cwt. pot. sulph.	2 7 0
No manure	1 12 2
6 cwt. super. + 1 cwt. ammon. sulph. ..	2 15 0
6 cwt. super. + 1 cwt. ammon. sulph. + 1 cwt. pot. sulph.	2 15 0
6 cwt. market garden	2 2 2
6 cwt. Basic phosphate	2 2 2

The above weights are for market-sized tubers only.

Table 4 shows the average yields over the three years during which trials have been conducted on these plots. From these it would appear that the super 6 cwt. + ammonium sulphate 1 cwt. is going to prove itself the best combination for this district as for the majority of Victorian potato soils. It will be noted that much heavier dressings of super.

are required for Gippsland country than for the volcanic soils of the State. In this case the super. applications are followed by a decided improvement in yield up to 6 cwt. per acre compared with an optimum dressing of 3 cwt. per acre in the case of the volcanic soils.

The figures for plot 7 again show a depression from potassic applications on this soil. In the case of polts 8 and 9 in Table 4, the yields given are for two years only, and the averages for the same period.

TABLE 4.—AVERAGE YIELDS, THREE YEARS.

Manures per Acre.	Average Yield.	Percentage Increase over No Manure.
	T. C. Q.	Per cent.
Super. 3 cwt.	6 7 3	50
Super. 6 cwt.	6 16 0	60
Super. 9 cwt.	5 18 1	39
Super. 6 cwt. + Pot. Sulph. 1 cwt.	6 4 3	47
No Manure	4 4 3	—
Super. 6 cwt. and Ammon. Sulph. 1 cwt.	6 18 2	63
Super. 6 cwt. and Ammon. Sulph. 1 cwt. + Pot. Sulph. 1 cwt.	6 13 1	56
Market Garden 6 cwt. ..	4 14 3	56*
Basic Phosp. 6 cwt.	4 11 1	51*

* Average two years only.

Childers.

Notwithstanding the moderate yields of marketable potatoes obtained at the 1930-31 harvest of the manurial trial plots at Childers, the results are highly satisfactory when taken in conjunction with those of previous years, as they show a very definite improvement from the various manures. The soil of this district has always proved to be very responsive to manurial treatment, and the consistency of the performance of the manures has been noticeable to a marked degree.

The season was very favorable to crops in the district until the end of February, when the potato crop suffered severely from leaf affectation of Irish blight. This caused almost complete defoliation, though fortunately in the majority of cases little tuber damage was done. The inevitable result was a very substantial reduction in the yields per acre.

Because of the information gained during the seven years prior to 1930, the application of superphosphate at the rate of 9 cwt. per acre was discontinued last season. The reason for this was the definite demonstration given by the results of the seven years mentioned that to apply super. in excess of 6 cwt. per acre was not such a profitable proposition as an application of 6 cwt. super. in conjunction with 1 cwt. ammonium sulphate per acre. This latter, the "6 and 1" dressing, has again shown its efficiency during the season just closed. The yield from the plot receiving that dressing showing an increase of 115 per cent. over the unmanured plot. This season potash shows to very great disadvantage. Whereas super. and ammonium sulphate gave an increase of 115 per cent.. the addition to this mixture of sulphate of potash at the rate of 1 cwt. per acre, despite the extra cost involved gave an increase of only 74 per cent. over the unmanured plot.

During the past season two variations of the rate of application of ammonium sulphate were introduced into the plots at Childers. In addition to the 1 cwt. ammonium sulphate given in conjunction with super. amounts of 1½ cwt. and 2 cwt. respectively were tried. Both of these, of course, were given along with 6 cwt. superphosphate to the acre, as it has been demonstrated that that quantity of super. is practically essential to good yields. For this single season's work the increase in the quantity of ammonium sulphate gave very striking results. With the "6 and 1" dressing the yield was increased by 115 per cent., while the "6 and 1½" dressing gave an increase of 165 per cent. Curiously enough a dressing of 6 cwt. super. and 2 cwt. ammonium sulphate brought the increased yield back to 105 per cent. The actual results are shown in Table 5 for the past year.

TABLE 5.—MANURE.

Manure.	Yield per Acre.	Percentage Increase.
	T. C. Q.	%
6 cwt. super. + 1 cwt. ammon. sulph.	3 10 0	115
6 cwt. super. + 1½ cwt. ammon. sulph.	4 5 2	165
6 cwt. super. + 2 cwt. ammon. sulph.	3 6 1	105

These results, of course, are inconsistent, but it should be remembered, however, that they are the outcome of only one year's work, and it remains to be seen from further trials

whether the increased dressings of ammonium sulphate will give, on the average, better returns, or whether the differences this year are due to some soil variations or seasonal conditions.

In this district the rainfall for the season was ample, and its incidence favorable for the complete functioning of the manures. The main governing factor in light tuber production was leaf affectation by blight (*Phytophthora infestaus*).

In the case of both market garden manure and basic phosphate, increases in the rates of the application from 3 cwt. per acre to 6 cwt. per acre were made for the years 1929-30 and 1930-31, and these heavier dressings seem to be acting very favorably, but further experimental work is necessary before their adoption in preference to super. can be recommended.

The Childers plots are located on a gravelly loam on the farm of Mr. W. Baird. The results for last season are set out in Table 6.

TABLE 6.—MANURIAL TRIALS, CHILDERS, 1930-31.

Manure per Acre.	Marketable Tubers.	Increase from Manures.	Percentage Increase.
	T. C. Q.	T. C. Q.	%
Super., 3 cwt. ..	2 17 2	1 5 0	78
Super., 6 cwt. ..	2 17 2	1 5 0	78
Super., 6 cwt. + ammon. sulph., 1 cwt. ..	3 10 0	1 17 2	115
Super., 6 cwt. + ammon. sulph., 1½ cwt. ..	4 5 2	2 13 0	165
No manure	1 12 2	..	..
Super., 6 cwt. + ammon. sulph., 2 cwt. ..	3 6 1	1 13 3	105
Super., 6 cwt. + ammon. sulph., 1 cwt., and pot. sulph., 1 cwt. ..	2 16 1	1 3 3	74
Market garden manure, 6 cwt.	3 0 0	1 7 2	84
Basic super., 6 cwt. ..	2 17 2	1 5 0	78
Di-ammonium phosphate, 3 cwt.	4 5 2	2 13 0	165

The yields recorded in Table 6 are for marketable-sized tubers only. Potatoes too small for inclusion in the yields amounted to an average of 2 tons per acre from all plots. As this large proportion of small potatoes was common to all plots during the past season, the proportional increases for different manures are not affected, but the yields shown are much lighter than they would have been normally.

At Childers a trial was made with a comparatively new manurial compound known as di-ammonium phosphate. This fertilizer contains 20.6 per cent. nitrogen and 53 per cent. phosphoric acid, all of which is in a water soluble form. The results from the compound were very satisfactory, as the yield equalled that from 6 cwt. super. and 1½ cwt. ammonium sulphate. However, the cost of di-ammonium phosphate at the present time is substantially more than for the dressing of super. and ammonium sulphate.

In the case of Childers, it is now possible to give the average returns for five standard manurial variations over a period of eight years. These are shown in Table 7. It will be seen that the "6 and 1" dressing is the best combination so far tried at Childers, giving the remarkable increase in the average yield of no less than 173 per cent. The addition of potash at the rate of 1 cwt. per acre to the "6 and 1" reduced the percentage increase for the period under review to 153 per cent. Super. at the rate of 3 cwt. shows a very material increase over no manure, but a substantially better yield is given by the dressing of 6 cwt. super. per acre.

TABLE 7.—AVERAGE RETURNS, EIGHT YEARS.

Manures per Acre.	Average Yield.	Percentage Increase.
	T. C. Q.	%
Super. 3 cwt.	4 10 1	105
Super. 6 cwt.	4 19 0	125
No Manure	2 3 3	—
Super. 6 cwt. + Ammon. Sulph. 1 cwt.	6 0 0	173
Super. 6 cwt. + Ammon. Sulph. 1 cwt. + Pot. Sulph. 1 cwt.	5 11 2	153

Navel Ill or Joint Evil in Foals

By W. M. Lerew, Veterinary Officer

NAVEL ill or joint evil is an acute infectious disease of newly-born animals, and is characterized by considerable swelling of the knee or hock joints or both. It develops as a result of infection of the umbilical cord or navel string by the causative organism; also as a result of the infection of the foal prior to birth. The infection takes place as a result of the umbilical cord, which is moist and blood-soiled, coming in contact at the time of birth with contaminated bedding or soil containing the organisms that cause the disease. The organisms which reach the navel string gain access to the blood clot in the torn blood vessels of the cord and pass along the vessels till they reach the blood circulation system, and are then carried to the joints of the legs, which have a special predisposition to their attacks. This infection is liable to occur till drying of the stump of the cord is complete.

If mares are allowed to foal in a loose-box and the disease manifests itself, all subsequent foalings will be exposed to the risk of infection. The foal may be born with the infection only when the mare is suffering from an infectious disease such as influenza, &c. The infection is conveyed to the unborn foal through the blood of the mother.

As the causative organisms can live and multiply in the soil, the disease need not be introduced from outside sources, but may result from direct contact with the soil. In acute cases sometimes the navel is swollen, its borders are ulcerated, and pus may be squeezed out. Abscesses often occur in the lungs and other internal organs. The principal changes occur in the joints of the legs, chiefly the knee and hock joints. These joints become swollen and distended with a pus-like synovia or "joint oil" which is yellow or reddish and semi-fluid.

Symptoms.

Symptoms generally appear in 24 to 48 hours after birth, and the first indication is a swelling of the navel, which becomes sensitive and warm to the touch, while the stump of the cord dries more slowly than usual. The affected animal dislikes moving, and its gait becomes stiff; it loses the desire to suck and becomes feverish. It lies continually, and if stood up soon collapses. Pulse and respiration are both accelerated, followed by symptoms of general blood poisoning. Constipation and colicky pains may appear, followed by diarrhoea. Emaciation is very marked, and the patient rapidly weakens and dies. Sometimes the disease takes a chronic form through the same stages, but in a slower and milder form. This is complicated by affection of the lungs, and death may occur after several weeks from exhaustion. In very acute cases death may result in two or three days.

An affected colt. Note the swelling of the right knee and left hock joints.

Treatment.

The navel should be treated by disinfection with warm antiseptic solutions, such as lysol or creolin, 2 per cent. When the swelling commences in the joints, it may be relieved by rubbing in grey mercury ointment. If the joint contains a large quantity of fluid, it will

[*Continued on page* 550

Orchard and Garden Notes

By Edward E. Pescott, F.L.S.

The Flower Garden.

PROPER attention given to chrysanthemum plants this month will result in satisfactory flowers in the autumn. Frequently, when the plants have made their strong spring growth, they are allowed to continue this growth without check, with the result that the plants become unduly tall, and produce too many mediocre blooms.

If the plants have grown freely, the stems should be cut down to within a foot of the ground, or even an inch or two less. They should then be mulched and watered. This will result in strong but sturdy lateral growth, which will give branching stems, capable of producing good blooms in the autumn. As the stems grow they should be tied to strong but unobtrusive stakes in order to keep the growths vertical.

In December dahlia tubers should be planted out in the garden. The soil should first be well worked over, digging into it a good layer of animal manure; a small amount of bone-dust may also be added. The whole tuber, as dug last winter, should not be replanted; it should be cut up into sections, each portion having an eye or bud on the attached stem. Thus an old tuber clump often may be cut into six or seven plants. The tuber pieces should be planted with the bud just below ground level, and a stake should be driven in so that the young growths may be tied to it as they appear.

When the weather becomes hot, and before the middle of December, the garden generally should be mulched with old stable manure, leaf mould or lawn clippings, to keep the soil cool, and to encourage root growth of the plants.

The Vegetable Garden.

Ample watering is necessary in the warm weather to keep the crop growing quickly and so produce succulent, crisp vegetables. This applies especially to the lettuce crop. In warm weather, and in the middle of the day, the lettuces may be grown almost under swamp conditions. Rhubarb beds also should be very well watered. Ample water, combined with manure, will produce the crisp brittle stems which are so desirable in rhubarb culture.

A cactus dahlia.

It is not yet too late to sow cucumber and gherkin seed, which should be sown in the open. It will germinate quickly at this season, and will bear succession crops to the plants set out earlier. These plants also need an abundance of water and manure.

Cutting in the asparagus beds should cease early in December. This gives the crowns a chance to grow the second lot of stems for strengthening purposes. As soon as cutting ceases, the beds should be quite heavily manured, using animal manure or seaweed for preference, or giving a good supply of blood manure instead.

In The Orchard.

Codling moth sprayings should be continued on the lines as suggested last month.

The common and almost universal subject of discussion at present is the attack of thrips. There is a consensus of opinion that the abundant damage done to the

fruit blossoms is not due entirely to the ravages of these insects. It is to be admitted that they have been very abundant this year. In many gardens the insects were plentiful in flowers in July and August, even though the weather then was both wet and cold.

It seems to be the opinion that the wet winter, combined with the rain in spring, and the irregular warm spell, has caused a rather weak and sappy growth. This tender growth will surely suffer when a sudden hot change comes. Possibly there are other factors as yet unknown causing the trouble.

At any rate, the advice of the entomologists should not be disregarded, and the white oil-nicotine spray should be continued. One spraying may not be effective; others will certainly be required.

One important work is the clean cultivation of the soil under and around the trees, so as to destroy all harbours and hiding places of the thrips.

Navel Ill in Foals

[*Continued from page* 548.]

have to be treated by a qualified veterinary surgeon, and if successful should be followed by recovery in from one to two weeks. The patient should be kept in a clean dry place, and nutritive diet such as milk, eggs, &c., must be given.

In the case of foals born in a loose-box, infection by this disease may be prevented by scrupulous cleanliness and adequate disinfection of the building and contents. Before the mare is put into the box the latter should be thoroughly disinfected and a plentiful supply of clean straw should be provided for the foal to drop on. If the mare is kept out of doors a clean grassed paddock should be used, so that the foal is not dropped in the dust or mud.

After the foal is born, the cord should be washed with 5 per cent. lysol solution or 1-1,000 corrosive sublimate solution, firmly tied with a previously disinfected string and cut off about 1½ to 2 inches from the navel. This should be done after the pulsation of the cord has ceased. The stump should be washed frequently with the disinfectant till it dries up and shrivels completely.

In the case of a mare that has had a foal affected previously, it is advisable to administer iodine of potash in 1 dram doses night and morning for one month before date due for foaling. The iodine of potash should be dissolved in half a pint of water, and either given as a drench or sprinkled over the feed.

Farm Produce Agents Act No. 3678

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* Previous lists printed in this *Journal* for July, pp. 366–8, and August, p. 405.

Professional Papers

[This section is devoted to professional papers and articles of a scientific character.]

An Investigation of the Non-thrifty Condition of Citrus Trees at Tresco

By Frank M. Read, M.Agr.Sc., Senior Horticultural Research Officer.

The work reported herein has been carried out by the writer under the authority of the Tresco Experiments Sub-Committee, which consists of Messrs. H. A. Mullett, Agricultural Superintendent, J. M. Ward, Superintendent of Horticulture, J. A. Aird, State Rivers and Water Supply Commission, Frank M. Read, Senior Horticultural Research Officer. The late Mr. S. A. Cock, Citriculturist, was also a valued member. Mr. A. G. Strickland, Horticultural Research Officer, has assisted in field work, the recording and examination of results, and in the hydrogen ion determinations. Messrs. J. L. Provan and H. L. Hatfield have also assisted in the field work. The chemical analyses have been carried out by the chemists of the Department under the supervision of Mr. W. R. Jewell, Agricultural Research Chemist.

THE general nature of the problem has been described in a previous report (34)*. On the Tresco settlement, of the 2,500 acres which were planted in 1913, or intended for planting, only a few hundred acres remain productive. A large proportion of the trees are in very poor health; while the trees on a considerable area have died out completely. The earliest indications of trouble occurred within five years of planting; and by 1925 a large area was involved. Since 1925 the extension of the affected areas has proceeded more slowly; but citrus trees have been gradually eliminated from all except a few favoured locations.

General Description of Settlement.

The Tresco Settlement lies in the Mallee, 8 to 10 miles from the River Murray, and 14 miles south of Swan Hill. It consists of two typical Mallee sand ridges running north and south, more or less parallel, and about 2 miles apart, and the intervening flat country.

The original vegetation of the ridges was Murray pine (*Callitris* spp.) and large Mallee scrub (*Eucalyptus dumosa*); and that of the flat country mostly medium to large Mallee scrub. Prior to the establishment of Tresco as an irrigation settlement by Australian Farms Ltd., in 1913, the whole area had been devoted to wheat-growing for some years, and is said to have been quite fertile.

Irrigation water is pumped from Lake Boga, and, from the main channels (first lift), the lower lying portions of the settlement are watered by gravitation. (See Fig. 1.) Water is pumped from this channel to higher land by individual block-owners on the western sand ridge, *e.g.*, R. A. Phillips and Mrs. Bethel. On the eastern ridge water is pumped to two higher main channels—the second lift channel, which supplies most of the land on the eastern ridge, and the third lift channel which supplies a relatively small area at the highest part of the ridge. The general lay-out of the settlement and channels may be seen in Fig. 1.

The health of the citrus trees divides the settlement similarly into three divisions. Good groves now occur only on the high parts of the ridges. On the main ridge, the productive groves occur in the third lift, and higher second lift regions. On the smaller western ridge good trees occur only on some of the higher parts. The water is pumped to these trees by individual block-holders. With the exceptions noted above, most of the groves on the rising ground—mostly watered from the second lift channel—are in poor health, and are not being cultivated, while on the flat land between the ridges, embracing practically all the citrus areas watered by the first lift channel, the trees are long since dead.

For five or six years after planting, the settlement flourished on all levels; but shortly after that stage, trouble became noticeable on the flats. Both vines and citrus began to die, and it was discovered that a water table had been formed within a few feet of the

* The numbers refer to literature cited at the end of the paper.

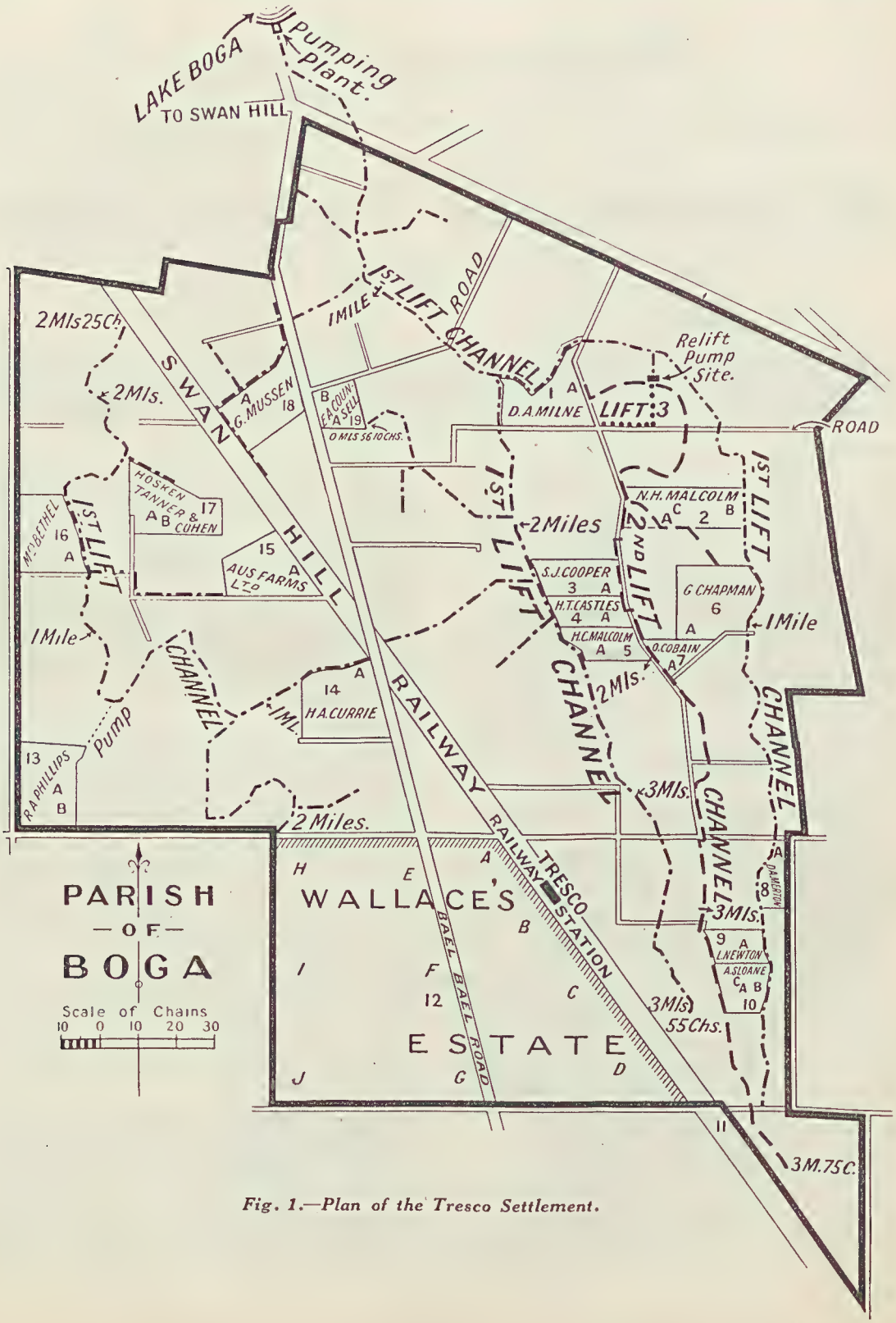

Fig. 1.—Plan of the Tresco Settlement.

surface. This condition doubtless was brought about by heavy irrigation on the flat land, together with seepage of surplus water from the adjoining ridges. Mineral incrustations on the surface of the soil were soon to be noticed; and in a year or two practically all the lower land was abandoned, both vines and citrus having succumbed. From that time on, patches of citrus, first on the rising ground, and later even on the hilltops, become unthrifty. The vines on the second and third lifts, however, have continued for the most part to yield good crops.

Prior to the establishment of experiments designed to discover a remedy for the trouble, one typical grove in each of the three main sections was examined in detail. The groves selected were—

1. N. H. Malcolm's (high second lift), a very good grove.
2. A. Sloane's (low second lift), an affected grove.
3. E. A. Counsell's (first lift), an abandoned block on which trees had been dead some years.

The location of these groves is indicated on Fig. 1, which shows also several other groves and areas on which less work has been done. The numbers and letters appearing on the blocks coincide with the numbers of the bores mentioned in the following tables. The letters have been placed to mark the exact location of the bore.

Soil Types.

Surface indications are sufficient to classify the Tresco citrus groves into three main types.* On the high part of the ridges, where most of the good groves occur, the soil is of a red sandy nature. In the profile described in Fig. 2, type I., it is 1 foot in depth; but in places the surface sand may be up to 3 feet deep. This soil is known locally as "Red Mallee," and its original vegetation is said to have been Murray pine and big Mallee scrub. It is extremely easy to work, and is practically self-mulching.

Fig. 2, type II., soil is known locally as "Grey Mallee." It occupies all the ridge country except the small area of "Red Mallee" referred to above. For the most part, the trees on the "Grey Mallee" soil are in poor health. The soil is not so easy to work as the "Red Mallee," and tends to form clods. Its surface colour is reddish grey; but in a freshly cut profile it appears dark brown. The original vegetation on this land was big Mallee scrub with occasional Murray pines.

Type III. soil is grey brown in colour when dry, though dark brown in a freshly cut profile. It occupies the flat country between the sand ridges. Practically all cultivation of this land has ceased owing to the death of citrus and vines. The original vegetation was Mallee scrub.

All three types are similar in the occurrence of a band of limestone, in both the nodular and soft forms, extending from a depth of 12 inches to 5 feet. Below 5 feet it rapidly disappears in types II. and III., and somewhat more gradually in type I.; although below 5 feet even in type I., it is not very conspicuous.

The great differences between the types are in texture. Type I. is light textured throughout; and at 10 feet a fine sand of indefinite depth occurs. The natural drainage properties of this soil are excellent.

Type II. is a little heavier in the top 4 feet than type I.; and below that depth a very impervious red clay occurs which increases in heaviness in depth until it suddenly gives place to a coarse sand at 21 feet. The appearance of this red clay layer, beginning at 4 to 6 feet from the surface, does not adequately indicate its impermeability, owing to the high percentage of sand which is mixed with the clay. Experience has shown, however, that this clay reduces to a minimum the natural under-drainage of the land.

Type III. is still heavier in nature; and from one foot below the surface is extremely impermeable to water. Although no opportunity for studying the behaviour of this soil under irrigation was offered, owing to its abandonment, it is clear that its great impenetrability would make efficient irrigation very difficult. Experience on Sloane's grove, type II., would suggest that it would be practically impossible, under the conditions which obtained at Tresco prior to this investigation, to prevent the formation of a water table close to the surface after irrigation.

The examination of these soils down to a depth of 8 feet was made by digging a pit. Below that depth boring with an augur or post-hole digger, whichever proved the more

* On the east and north-east boundaries of the Tresco settlement Grey Box flats occur; but since from a citrus growing point of view they are of no interest, they are not discussed.

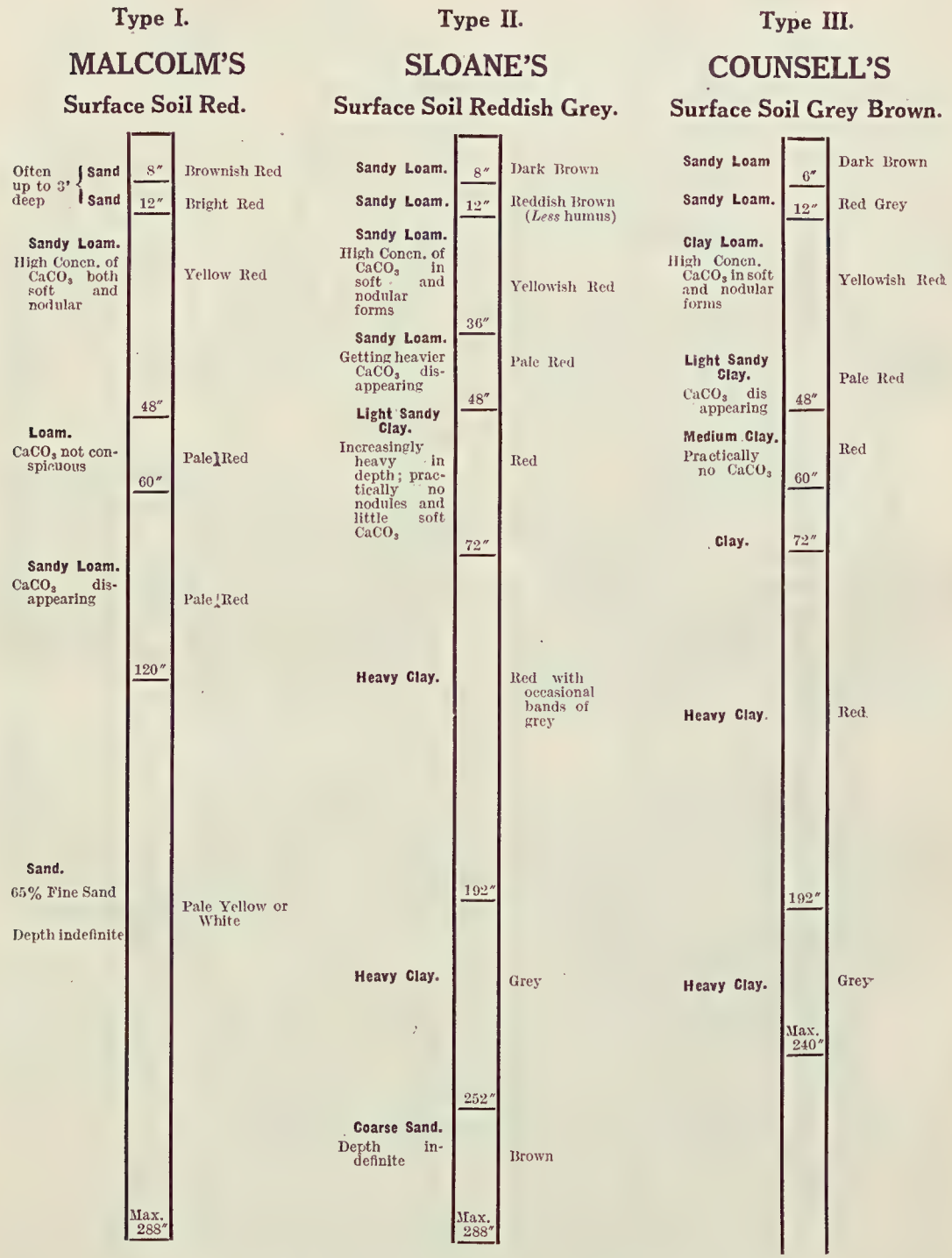

Fig. 2.—A diagrammatical representation of Tresco Citrus Soils.

suitable, was resorted to. Samples for analysis were similarly collected.

Mechanical Analyses.

Table 1 shows the mechanical analyses of the three types of soil; and when read in conjunction with Fig. 2, emphasizes the differences in their mechanical composition.

The surface soil, type I., contains 82 per cent. sand, and in no layer down to 72 inches does sand fall below 51 per cent. At 72 inches the sand content is 69 per cent. The clay content varies from a minimum of 7 per cent. to a maximum of 23 per cent.

Type II. surface soil shows 58 per cent. sand, and the minimum concentration, occurring at about 36 inches, is 39 per cent. Clay varies from 14 per cent. at the surface to 25 per cent. at 72 inches.

Type III. surface soil in mechanical analysis is not dissimilar from type II., being only slightly heavier, with 55 per cent. sand, and 17 per cent. clay. Sand falls to a minimum of 25 per cent. at 36 inches. Approximately the same depth as that at which the minima were recorded for types I. and II. The clay content increases steadily from 17 per cent. at the surface to 41 per cent. at 72 inches.

Fig. 3 shows the positions occupied by these three profiles on the distribution triangle.

It will be seen that in all three types silt is very low. The absence of silt and their high sand contents give to the heavy subsoils of types II. and III. an appearance of friability which masks their impermeable nature. The distribution triangle indicates that all these soils are of the same general type, varying only in their proportions of clay and sand.

To the right of the triangle the texture classification adopted (42) for the Renmark soil survey is indicated. For Tresco soils it is not altogether suitable owing to the very low silt content; and the higher percentage of sand.

TABLE 1.

MECHANICAL ANALYSES OF TRESCO SOILS.

Per cent. Air-dried Soil.

Type 1 (Malcolm's) [2 A].

	0–6″.	6″–12″.	12″–24″.	24″–36″.	36″–48″.	48″–60″.	60″–72″.
Coarse Sand	49·4	35·1	26·5	25·1	24·6	26·3	32·6
Fine Sand	32·6	35·3	25·1	26·3	28·3	32·7	36·7
Silt	1·8	1·0	0·3	2·1	2·9	2·2	0·9
Fine Silt	2·7	5·2	4·6	2·5	0·9	0·5	1·9
Clay	7·3	10·2	16·0	16·7	18·3	22·6	16·2
Loss on Acid Treatment	3·1	7·7	22·3	23·2	20·6	9·7	7·5
Loss on Ignition	3·5	5·6	12·1	12·2	11·2	6·6	5·1
Moisture	0·9	1·8	2·2	2·8	1·7	2·4	1·5
CO_2	0·6	2·6	8·7	9·2	9·1	4·0	2·8
Equivalent $CaCO_3$	1·4	6·0	19·8	20·9	20·8	9·1	6·4
Rubble*	Nil	Nil	32·0	24·0	12·3	12·0	14·0

Type 2 (Sloane's) [10 A].

	0–6″.	6″–12″.	12″–24″.	24″–36″.	36″–48″.	48″–60″.	60″–72″.
Coarse Sand	37·0	39·4	28·0	28·6	27·1	32·9	42·0
Fine Sand	20·6	14·5	11·6	10·3	12·0	12·5	13·9
Silt	1·5	1·9	0·5	0·5	0·1	0·8	1·3
Fine Silt	5·4	4·0	4·2	4·0	5·7	6·3	4·9
Clay	14·0	13·3	17·6	21·0	21·8	24·9	25·2
Loss on Acid Treatment	14·4	20·5	32·2	27·6	25·2	14·9	4·6
Loss on Ignition	10·0	12·0	16·9	16·4	15·4	9·3	4·8
Moisture	2·0	2·5	2·4	3·2	3·3	3·9	4·1
CO_2	3·0	6·5	13·4	11·0	9·1	3·9	0·5
Equivalent $CaCO_3$	6·8	14·9	30·4	25·0	20·7	8·9	1·4
Rubble*	3·0	12·9	13·9	23·7	21·4	12·5	2·6

TABLE 1.—*continued.*

Type 3 (Counsell's) [19 A].

——	0–6″.	6″–12″.	12″–24″.	24″–36″.	36″–48″.	48″–60″.	60″–72″.
Coarse Sand	36·4	33·6	25·9	15·0	15·3	21·3	24·4
Fine Sand	19·1	19·0	13·0	10·3	11·0	15·0	14·8
Silt	2·9	1·9	0·0	3·1	1·4	1·1	0·4
Fine Silt	7·3	5·3	3·1	0·4	2·4	4·7	7·0
Clay	16·6	17·9	24·2	22·9	24·5	33·8	41·2
Loss on Acid Treatment ..	11·5	15·4	28·3	42·5	39·7	12·8	2·9
Loss on Ignition	9·0	10·2	15·8	21·6	20·6	9·4	5·0
Moisture	2·6	2·2	2·3	3·4	2·3	5·7	3·7
CO_2	3·5	5·8	11·7	18·1	17·2	4·5	0·6
Equivalent $CaCO_3$	8·0	13·1	26·7	41·1	39·0	10·2	1·2
Rubble*	Nil	2·3	14·9	13·5	19·1	2·2	Nil

Type 2 (Unirrigated) [11].

——	0–12″.	12″–24″.	24″–36″.	36″–48″.	48″–60″.	60″–72″.
Coarse Sand	44·1	38·0	36·0	32·8	31·6	23·6
Fine Sand	18·4	14·3	13·3	20·7	15·5	12·4
Silt	3·2	1·5	3·0	2·0	1·3	1·1
Fine Silt	9·5	6·4	3·9	4·4	4·1	4·3
Clay	13·7	19·7	21·3	23·1	22·1	18·6
Loss on Acid Treatment ..	2·8	10·3	14·7	9·4	16·4	31·1
Loss on Ignition	4·9	7·7	9·3	6·9	10·0	16·5
Moisture	4·1	5·7	5·4	5·3	5·4	5·0
$CO^{\prime\prime}$	0·6	4·1	5·9	2·7	6·7	13·9
Equivalent $CaCO_3$	1·4	9·3	13·4	6·1	15·2	31·6
Rubble*	Nil	17·0	8·8	11·1	12·2	11·0

* The percentage rubble is very variable. The above figures serve only as a guide. Rubble excluded prior to analysis. The other constituents are expressed as percentage of the rubble-free sample.

One would be inclined, on their field appearances, to refer to the groups indicated on the diagram as sandy clay, light sandy clay, sandy loam, &c., instead of clay, light clay, and loam. The high sand content gives to all these soils and subsoils a gritty, sandy feel.

The calcium carbonate content, estimated from carbon dioxide, is interesting. It is high in all three types. In type III. it reaches over 40 per cent. at a depth of 36 inches; but has practically disappeared at 72 inches; while in type I. it has a maximum of only 21 per cent., but is spread over a much wider band, extending to a depth of 108 to 120 inches. This would suggest that the impenetrable nature of type III. had caused the deposition of the calcium carbonate in a narrow band; whereas in the permeable type I. soil its deposition in a much deeper band occurred. This would presuppose that the calcium carbonate had been deposited by downward leaching in the manner usual in most soils; but the huge amount present at Tresco, and in such Mallee soils generally, renders that improbable as a sole explanation. An adequate explanation of its occurrence is not yet forthcoming.

This calcium carbonate occurs both as nodules, and in the soft form as streaks or bands. Occasionally it forms a continuous rocky layer one to several inches thick at a depth of approximately 24 to 36 inches.

Table 2 gives a typical analysis of the nodules which consist of concretions of calcium and, to a much less extent, magnesium carbonates on a silicious nucleus.

Water Table.

Striking differences between the free water contents of the soil from groves of one type and those of another were found to occur.

On Malcolm's grove, type I., no free water was to be observed to a depth of 24 feet. Perforated galvanized iron tubes 8 feet long

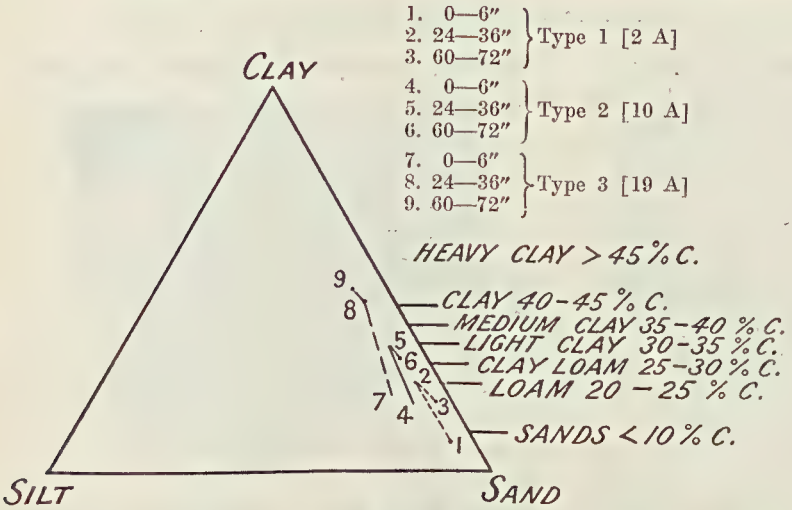

Fig. 3.—Distribution Triangle illustrating mechanical analyses, on an ignited basis, of soil types at Tresco to 72 inches (See Table I). To the right of the triangle is shown the texture classification adopted in the Renmark Survey (42).

were sunk in this grove to their full depth. During several irrigations they were observed, and at no time did they disclose free water within 8 feet of the surface, despite the fact that they were within 6 to 8 feet of an irrigation furrow on either side, and that water was running in the furrows for 35 hours. Excellent natural under-drainage is thus disclosed.

TABLE 2.

ANALYSIS OF LIMESTONE NODULES, TRESCO.

	%
Insoluble in HCl	30·2
Iron and Alumina ($Fe_2O_3 + Al_2O_3$)	5·2
Carbon Dioxide CO_2	27·3
Lime (CaO)	30·1
Magnesia (MgO)	4·0

On Sloane's type II. grove boring disclosed a water table close to the surface over a considerable area. Fig. 4 (*a*) illustrates the position at the time of the first examination. The graph is based on data from 150 bores uniformly scattered over the area. It shows the waterlogged area to consist, roughly, of a large semi-circle having the irrigation ditch A B as its base. There is also the definite tongue extending to the bottom of the grove in the south-east part, and a very small localized patch in the north-east corner.

After the succeeding irrigation, which was applied by the grower in the usual way, the position was found to be as shown in Fig. 4 (*b*). It is not known how much water was applied, as no reliable means of measurement was available. Probably not less than 6-acre inches of water was used.

Figs. 5 and 6 show the surface contour plan of the grove, and the contour plan of the surface of the underlying red lay layer respectively. Neither of these throw any clear light on the distribution of the water table. The surface contour plan (Fig. 5) shows that it is the highest point on the block, which is the wettest—the lower portions being dry.

Figure 6 shows that the surface of the underlying impermeable clay layer is thrown into folds which do not conform with the soil surface, and would, therefore, complicate irrigation, and natural underground drainage. The disposition of this clay layer, however, throws no light on the water table.

The explanation is simple. It was disclosed by a close scrutiny of the irrigation referred to above. The head ditch A B (Fig. 4) was seen to be badly graded, and the checks provided were quite inadequate to maintain an even head of water in the ditch, above the soil surface, along its length. This was aggravated by the fact that the outlet pipes were of too small capacity, and no means of regulating the flow from each was provided. They were found to vary both in diameter and in length. Thus each furrow received a volume of water, governed by (1) the head of water in the ditch at the point, and (2) the capacity of the outlet pipe. No effort had been made in the construction of the ditch to make these uniform at all points, nor was it possible to regulate them.

Fig. 5 shows that the fall of the land in an easterly direction from the ditch near A is small. In irrigating, it was seen to be almost level for some distance; and, as the channel was low at the point, and the pipes small, the water could be forced along the furrows only with difficulty and by keeping them very full. Under these conditions the soakage from these

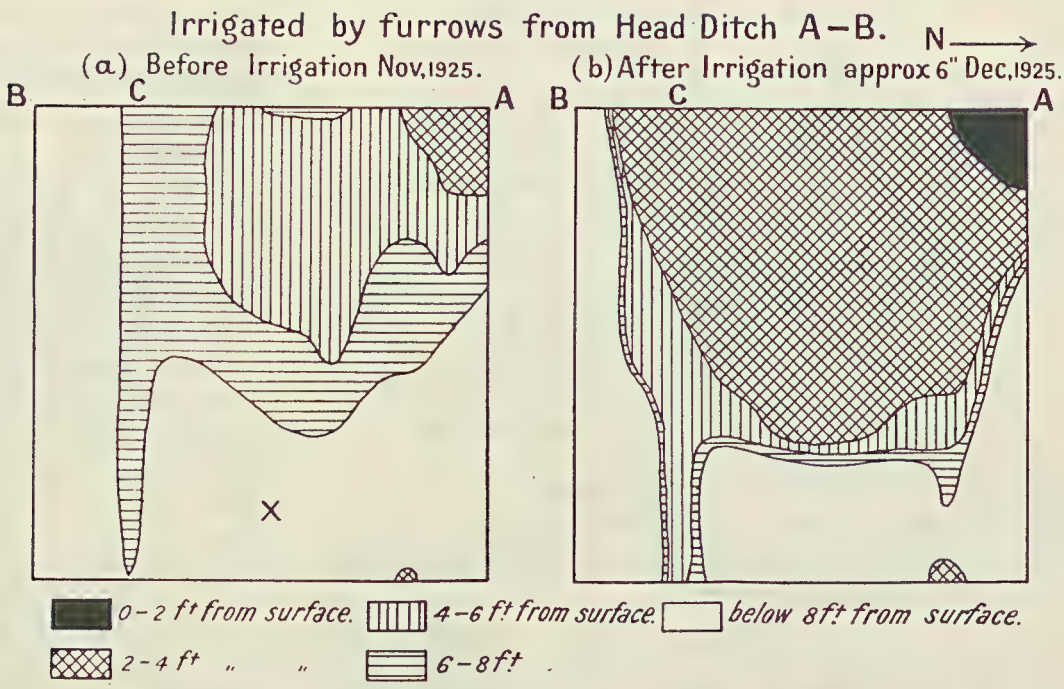

Fig. 4.—Showing depth of water table from surface, Sloane's Grove, Tresco.

furrows was abnormally high, and the high water table in the north-west corner was produced. The bottom two-thirds of the run received much less than their normal share of irrigation water, and were enabled to remain free of water to 8 feet.

At the point C on the head ditch A B a concrete stop occurred. This stop was seen to produce a big head of water over the pipe just above it, and cause a much larger flow than the average. This furrow coincided exactly with the tongue shown in Fig. 4 (*a*) and (*b*), and doubtless explains the reason for its presence.

The small patch near the north-east corner was due to a leakage from an earthen head ditch supplying a field to the east of the experimental area. This defect in the ditch was remedied, and the patch eliminated. From the contour plan (Fig. 5), it is seen that from C to B in the head ditch the fall is much greater than from A to C. This steep fall was not provided with adequate checks; and consequently the area watered by the portion C B received much less water than the remainder of the field, owing to the head of water being very low.

Taking the area as a whole, it will be seen that the top two-thirds are waterlogged, while the bottom one-third is free of excess water. This was found to be due to the excessive length of the furrows—10 chains. Water was running past the top trees for about 36 hours, while the lowest trees received it for only six hours or less. In a previous article (34) this aspect is fully described, and an account given of experiments carried out to test the conclusions drawn. The experiments indicated that for efficient watering on this type of soil runs longer than 3 to 4 chains were undesirable.

On the north, east, and southern boundaries of the grove trees of better health were to be seen. The badly affected patch consisted of a huge semi-circle practically coinciding with that shown for the water table. Fig. 7 gives a view of the grove from the western boundary looking east from a point about midway between A and C. The better trees to the north and east can be seen. The foreground consists of affected trees cut back. Two additional ditches which reduced the irrigation run to little more than 3 chains can be seen in the photograph.

Thus in Sloane's grove a water table occurred, and appeared to be associated with the death of the trees. It should be understood, however, that there were affected trees outside

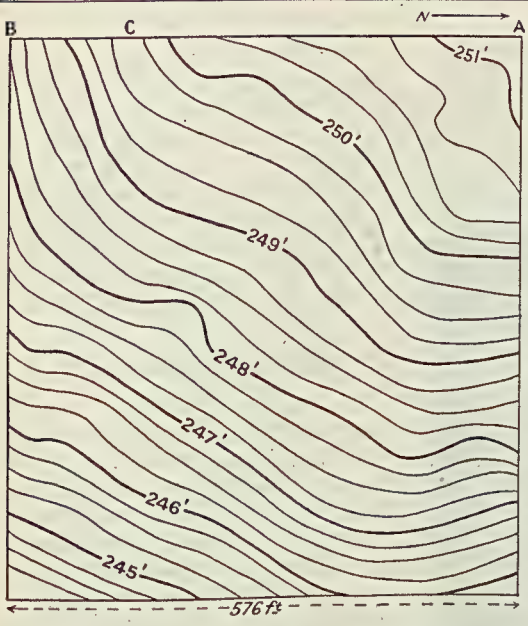

Fig. 5.—Surface contour plan, Sloane's grove.

the waterlogged area; though they were rarely so badly affected as the majority of those in the central semi-circle.

Citrus chlorosis and dying back have been attributed elsewhere (5) to just such a waterlogged condition of the root zone, and heavy underlying subsoil as occurs at Tresco in groves of this type.

The data given above afford a striking example of the manner in which a carelessly designed irrigation layout can affect the success of an irrigation area. It points to the necessity for a much more careful scrutiny of such works than has been the custom at Tresco in the past.

No opportunity occurred to study the water table on the type III. soil in relation to irrigation. Reliable local authorities, however, say that when, a few years after the establishment of the settlement, trouble became noticeable on this flat land, a water table was discovered within 2 feet of the surface. At the present time, free water occurs in the normal winter season at 4 to 5 feet from the surface, and a little lower during the summer. Seepage from the adjoining higher land usually has been blamed for this free water on the flats; but it is obvious, from experience on Sloane's grove and what is known of the nature of the type III. soils, that it would be very difficult to irrigate such soils without causing a water table. It would seem that, though seepage from the higher land accentuated the position, the water table formed on the flat land was due largely to excess irrigation, and, as we shall see, poor irrigation properties of the soil.

Deeper Water Table.

The water table referred to above on the irrigated groves, occurs near the surface, and

Fig. 6.—Contour plan of the red clay subsoil, Sloane's Grove.

Fig. 7.—A view of Sloane's grove as subsequently laid out for flood irrigation. Part of the affected semi-circle can be seen in the foreground with better trees to the north and east.

would appear to be due entirely to the holding of irrigation water in localized areas by the very impervious clay subsoil. There is evidence that, at a greater depth, a water table may be found over the whole countryside.

At the point X on Sloane's grove, Fig. 4 (a), free water was met at 15 feet from the surface. On Mr. H. Castles's grove a water table occurred in parts within 5 feet of the surface; but in other parts it did not occur until 16 feet. Then again on Mr. Lambert's property in the bore referred to in Table 6 as No. 7 water was struck at 12 feet. This land has not been irrigated, and is not within half a mile of the nearest irrigated land. Mr. H. Castles states that in the 1902 drought when boring for water on his property, some miles west of Tresco, he encountered brackish water at about 20 feet; and Mr. H. B. Martin records the same experience in 1914 on the Tresco settlement.

On Mr. Sloane's grove, it is found usually that the water table (determined by boring) falls very slowly indeed until it reaches 6 to 7 feet, but thereafter it seems to fall almost immediately to a depth of 16—18 feet. Fig. 4 indicates how rapidly the water table falls away at the edges of the water-logged areas.

Water Soluble Salts.

In Table (3) are shown analyses for water soluble ions in the three types of soil. It will be seen that type III. is very high in total solids, and quite unfit for irrigated horticulture. In fact it is improbable that it could be economically used for any purpose. The principal ions accounting for the differences in total solids between types I., II. and III. are chlorine and sodium. Chlorine reaches a maximum of only 16 parts per 100,000 in type I. In type II. the maximum occurs in the top foot where 87 parts per 100,000 are found. In type III. chlorine reaches huge proportions—815 parts per 100,000. Sodium, it will be noticed, varies from type to type in the same manner as chlorine.

There do not appear to be important differences between the good type I. and the affected type II. with respect to sulphate, carbonate, bicarbonate, lime, and magnesia; though magnesia is a little higher, and lime a little lower, on the whole, in Sloane's than in Malcolm's. It is of some interest to observe that soluble potassium is about ten times as high in type I. as in type II., despite the fact that, in the routine soil analysis (Table 7) potash is higher in type II. than in type I.

In types II. and III. there is a very high concentration of salts near the surface. Shaw and Smith (40) have shown that the rise of soil water to and evaporation at, the surface is enormously increased by the presence of a water table close to the surface; and it would appear that here this factor has been in operation.

TABLE 3.

WATER SOLUBLE SALTS, TRESCO, IN P.P. 100,000 OF SOIL.

Malcolm's Good Grove [2 A], Type 1.

Depth.	T.S.	Cl_2.	SO_4.	CO_3.	HCO_3.	CaO.	MgO.	Na.	K.
0–6″ ..	130	4	12	..	49	18	7	..	22
6″–1′ ..	124	12	24	..	55	18	7	9	14
1′–2′ ..	92	14	17	..	67	18	7	11	13
2′–3′ ..	100	8	16	6	61	13	8	5	26
3′–4′ ..	116	6	12	..	97	10	7	24	15
4′–5′ ..	240	16	19	12	134	10	7	42	26
5′–6′ ..	240	10	14	18	104	10	5	35	22

Sloane's Affected Grove [10 A], Type 2.

Depth.	T.S.	Cl_2.	SO_4.	CO_3.	HCO_3.	CaO.	MgO.	Na.	K.
0–6″ ..	306	87	32	..	72	30	16	83	2
6″–1′ ..	260	70	28	..	72	22	15	73	3
1′–2′ ..	190	38	18	..	81	7	10	59	2
2′–3′ ..	180	24	18	..	106	5	8	58	2
3′–4′ ..	180	14	9	..	109	4	6	60	2
4′–5′ ..	182	12	5	12	115	4	7	52	2
5′–6′ ..	190	12	5	6	120	5	7	55	2

Counsell's Salt Pan [19 A], TYPE 3.

Depth.	T.S.	Cl_2.	SO_4.	CO_3.	HCO_3.	CaO.	MgO.	Na.	K.
0–6″ ..	1,820	815	50	..	43	148	41	565	26
6″–1′ ..	550	200	44	..	67	8	8	154	22
1′–2′ ..	550	185	40	..	92	3	7	148	22
2′–3′ ..	620	200	48	..	73	3	10	211	30
3′–4′ ..	620	235	50	..	134	3	10	203	23
4′–5′ ..	580	240	53	..	116	3	7	210	18
5′–6′ ..	630	245	65	..	134	..	8	197	18

Unirrigated [11], Type 2.

Depth.	T.S.	Cl_2.	SO_4.	CO_3.	HCO_3.	CaO.	MgO.	Na.	K.
0–1′ ..	80	20	12	..	67	16	9	19	2
1′–2′ ..	192	34	12	6	115	10	14	59	3
2′–3′ ..	320	89	41	3	151	16	13	114	3
3′–4′ ..	368	79	61	..	127	16	9	135	4
4′–5′ ..	376	98	52	3	133	12	14	112	2
5′–6′ ..	440	146	72	..	112	11	18	143	2

The following is the distribution of chlorine in a typical bore in the affected area of Sloane's, December, 1926:—

Depth.	Chlorine Parts, per 100,000.
0–2 inches	332
2–12 inches	36
12–24 inches	31
24–36 inches	18
36–48 inches	12
48–60 inches	10
60–72 inches	8
72 84 inches	7
84–96 inches	6

Malcolm's grove, where no water table occurred, shows no marked tendency to develop a high concentration of soluble salts near the surface. On the other hand, owing to good natural drainage and heavy watering, there has been some tendency for salt to move downward. Veihmeyer (46) has shown that under normal conditions such as these the rise of soil moisture to the surface is negligible.

This aspect has been fully discussed in a previous article (34) wherein is reported a successful experiment based on the reasoning that judicious flood irrigation instead of the usual furrow irrigation, would tend to disperse this chlorine in depth, and therefore lower the maximum concentration in the root zone.

In type II. bicarbonate is higher than chlorine, but since the concentrations are practically the same in both other types it has been concluded that this does not contribute directly to the ill-health of the trees.

Table (4) shows the chlorine content of several groves in relation to the health of the trees at the time of sampling. It must be realized that the estimation of chlorine at any one time in this way can give only very general information on the tolerance of the orange to

TABLE 4.

CONCENTRATION OF CHLORINE (Cl_2) AND THE HYDROGEN ION CONCENTRATION (pH) IN TOP SIX FEET OF TRESCO SOILS.

The health of the Citrus Trees, where present at time of sampling, is indicated.

——	Soil Type.	Health of Trees.	Chlorine in part per 100,000 of Dry Soil.				pH. (Quinhydrone Electrode) at 20° C.			
			0–6".	6"–24".	24"–48".	48"–72".	0–6".	6"–24".	24"–48".	48"–72".
N. H. Malcolm [2 A] ..	1	Good	4	13	7	13	8·74	8·62	8·69	8·87
,, [2 B] ..	2	,,	14	14	12	12	8·94	8·80	9·14	9·15
R. A. Phillips [13 A] ..	1	,,	2	3	8	8	8·40	8·60	8·60	8·90
G. Chapman [6 A] ..	2	,,	7	29	27	6	8·90	8·90	9·00	9·10
H. C. Malcolm [5 A] ..	1–2	Fair	35	35	30	30	8·53	8·51	8·76	8·78
R. A. Phillips [13 B] ..	1	,,	30	45	25	30	8·39	8·28	8·76	8·85
A. Sloane [10 B] ..	2	,,	30	20	8	5	8·70	8·75	8·94	9·09
Mrs. Bethel [10 A] ..	1	,,	25	40	35	35	8·74	8·46	8·76	8·97
D. A. Merton [8 A] ..	2	,,	25	35	45	40	8·65	8·74	9·10	9·08
D. A. Milne [1 A] ..	1–2	Poor	35	60	40	25	8·58	8·51	8·76	8·94
H. T. Castles [4 A]	2	,,	40	60	35	50	8·86	8·71	9·03	9·12
G. Mussen [18 A] ..	2–3	,,	85	50	35	40	8·78	8·78	9·10	9·26
A. Sloane [10 C] ..	2	Bad	64	30	18	12	8·89	8·86	8·94	9·10
O. J. Cobain [7 A] ..	2	,,	50	55	50	40	8·94	8·71	8·97	9·12
L. Newton [9 A] ..	2	,,	80	55	35	35	8·58	8·72	8·89	9·01
H. A. Currie [14 A] ..	2	,,	25	35	40	75	8·72	8·84	8·81	9·12
S. J. Cooper [3 A] ..	2	,,	55	45	40	50	8·81	8·85	9·03	8·99
Hosken and Co. [17 A]	2–3	,,	70	75	35	50	8·74	8·69	8·99	8·85
E. A. Counsell [19 B]	3	Dead	1,520	660	475	335	7·94	8·05	8·23	8·23
Aust. Farms Ltd. [15 A]	3	These areas of flat land never planted up. Appearance always salty	545	560	445	370	7·98	8·08	8·40	8·33
Wallace [12 A] ..	3		264	486	382	324	..	..	..	..
,, [12 B] ..	3		1,102	496	382	438	..	..	..	..
,, [12 C] ..	3		2,262	524	344	362	..	..	..	..
,, [12 D] ..	3		244	266	228	180	..	..	..	..
,, [12 E] ..	3		876	466	418	424	..	..	..	..
,, [12 F] ..	3		7,900	854	502	468	..	..	..	..
,, [12 G] ..	3		3,124	696	444	378	..	..	..	..
,, [12 H] ..	3		324	306	264	262	..	..	..	..
,, [12 I] ..	3		174	572	336	224	..	..	..	..
,, [12 J] ..	3		344	986	664	222	..	..	..	..

chlorine. It may be that at certain times prior to the investigation soluble salts tended to concentrate in certain zones—for instance, in the surface layers during the hot summer months, or at the depth of penetration of the winter rainfall—and that such conditions existing for only a short time caused the poor health or death of the trees. Again, it is known that in the earlier years of the settlement the concentration of chlorine in the irrigation water frequently was high. During 1922, when the State Rivers and Water Supply Commission assumed control of the settlement, chlorine was found to reach over 60 parts per 100,000 in the irrigation water, and it is considered that in earlier years it was much higher. Kelly and Thomas (22) have shown the irrigation water to be a frequent cause of failure in California; and no doubt considerable damage was done at Tresco.

Table 5 gives analyses of the water, and shows that since 1922 a progressive improvement in quality has taken place.

Despite these interacting factors, however, Table 4 gives a general idea of the relation between chlorine and tree health at time of sampling. The maximum concentration of chlorine reached in any of the good groves listed is 29 parts per 100,000, and in every good grove except Chapman's it does not exceed 14 parts per 100,000 of dry soil.

In the groves classed as fair at the time of sampling, the maximum chlorine content falls between 30 and 45 parts per 100,000; while in each of the poor or badly affected groves it exceeds 55 parts, and rises in some to 85 parts per 100,000. Table 4 shows also the chlorine content of another part of Counsell's type III. area, whereon the trees died a few years after planting; and similar areas, shown as numbers 12 and 15 on the plan of the settlement, Fig. 1, which have never been planted up. It will be seen that in all these cases the chlorine content is very high indeed, and quite beyond the limits of successful irrigation.

From this data, and a knowledge of Californian experience (22) (35) (36) the conclusion was reached that a toxic concentration of chlorine was associated with the death of citrus trees at Tresco; and that tree health probably could not be maintained when a concentration of 30 parts or more per 100,000 of dry soil occurred in the top 6 feet of soil.

Chlorine Content of Deeper Horizons.

Table 6 shows the occurrence of chlorine in a number of deep bores sunk on the Tresco settlement, and two others on Mr. Lambert's farm, which is situated on the nearest sand ridge to the west of Tresco. For those who do not know the Mallee country, it should be said that it is undulating in nature consisting of sand ridges running approximately north and south, and intervening flat country. The ridges in this part are 1 to 2 miles apart. Mr. Lambert's farm is not irrigable, and is not within a mile of irrigable land. It can therefore be assumed that it is now in much the same condition as was Tresco prior to the establishment of the irrigation settlement.

Several important points emerge from the table. In the first place it is disclosed that

TABLE 5.

SALINITY OF TRESCO IRRIGATION WATERS, 1922–1931.

Season.	Average Concentration for Season in parts per 100,000.									
	Total Solids.	Cl_2.	NaCl.	SO_4.	CO_3.	HCO_3.	CaO.	MgO.	Na.	K.
1922–23	90	40*	62	3	..	14	..	..	..	..
1923–24	..	..	41	..	..	..	..	..	..	..
1924–25	..	..	28	..	..	..	..	..	..	..
1925–26	..	..	25	..	..	..	..	..	..	..
1926–27	34	12	20	1	Nil	7	3	3	11	0·9
1927–28	32	11	18	1	Nil	12	3	3	11	0·9
1928–29	31	9	15	1	Nil	11	3	3	10	0·8
1929–30	30	12	20	1	Nil	13	3	3	7	0·4
1930–31	32	12	20	2	Nil	12	4	3	6	2·0

Since the State Rivers and Water Supply Commission assumed control of the settlement in 1922 a great improvement in the quality of the irrigation water has taken place.

Complete figures prior to 1926 not available.

* At times during 1922–23 chlorine exceeded 60 parts per 100,000.

chlorine in most bores increases very considerably in depth. As the boring was done by hand, the depths indicated were the greatest it was found possible to reach, but they are sufficient to indicate that beneath the whole area there are layers very highly charged with soluble salts.

Secondly, it will be seen that Malcolm's grove in depth is remarkably free from chlorine. Probably, however, if we were able to penetrate further we should meet a saline horizon.

Bore No. 2 (Table 6) is situated at the crest of Mr. Lambert's sand ridge, and is similar in location to Malcolm's. It was found, however, to be intermediate in type between I. and II. Its chlorine content is higher than Malcolm's, but still relatively low. On the flat land the high chlorine content is to be found quite near the surface both at Lambert's and at Tresco.

Thirdly, there will be seen a difference in distribution between the irrigated and the non-irrigated areas. In the bores 2, 6, 7 which have not been irrigated the minimum concentration of chlorine occurs at the surface; while on each of the irrigated areas 1, 3, 4, 5, 8, it occurs some distance below the surface. Bore 1 can be disregarded as its chlorine content is so low throughout. Two forces would appear to be at work in the ascent of chlorine, (*a*) diffusion and (*b*) capillarity. In the unirrigated areas diffusion is probably the more important since the lower layers are moist, and capillarity quite unimportant, as we would expect (40) (46) where no free water occurs near the surface. In the irrigated soil, diffusion occurs just as in the unirrigated; but near the surface, where a water table is produced, capillarity begins to function, and tends to produce a concentration of soluble salts at the surface.

TABLE 6.

SHOWING CONCENTRATION OF CHLORINE (Cl_2) IN PARTS PER 100,000 OF SOIL IN TYPICAL TRESCO BORES.

A horizontal black line in each column marks the height of the water table, if present.

Cl_2 in p.p. 100,000 in blocks sampled.*

Depth of Sample.	1.	2.	3.	4.	5.	6.	7.	8.
0–1′	12	3	25	47	73	16	1	754
1′–2′	11	5	20	30	51	34	6	212
2′–3′	10	42	7	20	24	52	5	216
3′–4′	8	20	8	15	21	92	26	222
4′–5′	10	94	5	13	15	138	92	246
5′–6′	10	92	5	12	9	166	150	254
6′–7′	11	114	5	8	12	178	178	310
7′–8′	12	108	5	6	16	166	190	212
8′–9′	10	111	13	10	30	146	190	236
9′–10′	10	114	22	13	43	148	190	256
10′–11′	10	111	35	25	82	270	229	286
11′–12′	10	108	75	50	129	284	262	304
12′–13′	11	104	92	80	206	278	275	320
13′–14′	12	100	120	97	270	316	290	320
14′–15′	12	102	140	115	..	270	295	396
15′–16′	14	105	145	130	..	268	300	350
16′–17′	15	104	152	130	..	278	335	414
17′–18′	16	104	167	137	..	304	370	506
18′–19′	14	104	190	152	..	320	400	488
19′–20′	12	104	210	153	..	300	410	482
20′–21′	10	104	237	..	..	..	435	..
21′–22′	10	105	231	..	..	..	462	..
22′–23′	..	..	225	..	..	..	..	..
23′–24′	..	..	215	..	..	..	..	..

*1. Type 1. N. H. Malcolm's Good Grove [2 c] on Tresco plan.
2. Intermediate Type 1–2. Lambert's Sand Ridge about 4 miles west of Tresco main ridge. Used for dry farming.
3. Type 2. A. Sloane's Grove [10 b], where fair trees occurred.
4. Type 2. A. Sloane's Grove [10 c], where bad trees occurred.
5. Type 2–3. Hosken, Tanner, and Cohen [17 b], trees poor.
6. Type 2. Unirrigated land, Railway Reserve, ¼ mile South Tresco Station [11].
7. Type 3. Lambert's flat land at foot of 2 used for dry farming, and not within 1 mile of nearest irrigation land.
8. Type 3. E. A. Counsell's flat land, when citrus died very early [19 c].

TABLE 7.

ROUTINE SOIL ANALYSIS OF GOOD AND AFFECTED GROVES, TRESCO.

Concentration Per cent. Air-dried Samples.

	Type 1. Malcolm's—Good.			Type 2. Sloane's—Affected.		
	0–6″.	6″–2′ 0″.	2′ 0″–4′ 0″.	0–6″.	6″–2′ 0″.	2′ 0″–4′ 0″.
Nitrogen	0·039	0·038	0·020	0·067	0·043	0·025
Phosphoric Acid	0·056	0·054	0·038	0·060	0·041	0·029
Potash	0·580	1·619	0·538	0·677	0·753	1·455
Lime	0·512	3·152	9·224	3·776	8·240	9·504
Magnesia	0·429	0·625	1·610	0·729	1·207	2·563
Loss in Ignition	4·40	7·60	14·80	12·90	13·60	15·80

The point of practical importance is whether or not the deep saline layers constitute a danger under irrigation. It seems that the danger from diffusion is not great, otherwise it already would have increased greatly the concentration in Bore 3 at depths 4—8 feet and in the Bores 4 and 5 also. If then the force of capillarity could be controlled, by preventing a water table near the surface, the deep saline layers would not be likely seriously to contribute chlorine to the surface layers. Even if capillarity still tended to cause a surface concentration, however, it is possible, as has been stated previously, to leach this salt down again periodically by flood irrigation. Thus it would not appear that, on the type II. soils at any rate, the deep saline layers would prevent successful irrigation. On type III. where very high concentrations occur right to the surface the position would appear to be hopeless.

It is probable that the surface accumulations of chlorine have been caused, not by capillarity only, but also by the application of saline irrigation water. In either case, however, the same control measures suggest themselves (*a*) leaching out of chlorine by tile drains, and (*b*) dispersal of chlorine in depth by flood irrigation.

Routine Soil Analyses.

The routine analyses of Malcolm's grove and Sloane's affected groves are set out in Table 7.

Both nitrogen and phosphoric acid are low, and these two fertilizers find extensive use in the district. Potash would appear to be plentifully supplied, and, if anything, is higher on the affected grove. It will be remembered, however, that water soluble potassium is ten times as high in type I. as in type II. soils; and it may be that, in the latter, it is relatively less available to plants. Field experiments would be necessary to determine whether or not potash fertilizers would be beneficial on type II. soils.

Both lime and magnesia are higher in the poor grove than in the good one, and it has

TABLE 8.

HYDROGEN ION CONCENTRATION (pH) OF SOIL OF TRESCO CITRUS GROVES.

(Quinhydrone Electrode.)

	Type 1. Malcolm's [2 A].	Type 2. Sloane's [10 A].	Type 3. Counsell's [19 A].
0–6″	8·74	8·92	8·28
6″–1′	8·53	8·92	8·51
1′–2′	8·69	8·81	8·47
2′–3′	8·58	8·87	8·43
3′–4′	8·75	9·07	8·54
4′–5′	8·89	9·01	8·53
5′–6′	8·83	9·02	8·60

been the invariable experience that on any grove, if limestone rubble outcropped at any point, the trees succumbed the soonest on that area. It may be that this exceedingly high lime content is inducing chlorosis in the trees (6), (17), (44); but so far no success has been gained in introducing soluble iron salts into affected trees either by spraying the foliage or injecting a solution into the main arms. The introduction of the dry salt (iron phosphate) (47) has also been tried without any success to date.

The loss on ignition is higher on Sloane's than on Malcolm's owing to the higher content of alkali earth carbonates; but also to the higher content of organic matter which has been derived from several well-grown green manure crops of peas and beans. On the good grove as we have seen a free water table never occurs; and the trees keep the soil so dry that a green crop cannot grow luxuriantly except in a very wet winter.

Hydrogen Ion Concentration.

The pH. values for the three typical groves are given in Table 8. These determinations were made with the quinhydrone electrode by the method which has become the standard for soil work in Victoria (33). It is realized that serious limitations to the accuracy of this electrode occur in the range covered by most of these samples. Nevertheless the values are reproduceable, and serve as a basis for the comparison of the soils examined.

Table 9 shows the pH. values obtained in a profile from Sloane's grove by the quinhydrone, antimony, and hydrogen electrodes. These determinations were made by Mr. R. J. Best, of the Waite Research Institute, in the course of the extensive comparisons which he made of these three electrodes (2). As a result of his work, the antimony electrode recently has been successfully used in the study of such alkaline Mallee soils.

Type II. soils have the highest pH. values. Although type I. soils are lower in reaction (see also Table (4)), it is not clear that this of itself has a direct bearing on the health of the trees because, in the case of G. Chapman's good grove, the reaction varies from 8.90 at the surface to 9.10 at 6 feet, which is approximately the same as on Sloane's affected area. On D. A. Milne's and Mrs. Bethel's groves the pH. is rather low (Table 4); but the trees are in fair condition only.

The higher pH. values of type II. soils as compared with type I. are probably due to their higher concentration of replaceable sodium, Table 10. Type III. soils, although higher in replaceable sodium than type II., are seen to be lower in pH. This is due to their much higher soluble salt content. The high concentration of soluble salts prevents the hydrolysis of the sodium zeolites, and the consequent liberation of hydroxyl ions. Were this soil to be freed of its soluble salts by leaching, it would become progressively more alkaline in reaction until it reached a value at least as high as in type II. In this way saline soils such as type III. may be converted into alkaline soils such as type II. (6), (11), (24), (26), (45).

Table 4 (19B and 15A) shows that where the chlorine content is even higher than it is in (19A) Tables 8 and 3, the pH. value is depressed still further by the presence of higher concentration of sodium salts.

From the data secured, it can not be said that a relatively high pH. is a definite limiting factor to successful citrus-growing at Tresco; although from general principles of plant physiology and certain evidence for citrus in particular (37), it would appear that a reduction in pH. of the type II. soils would be desirable.

TABLE 9.

COMPARISON OF HYDROGEN, ANTIMONY, AND QUINHYDRONE ELECTRODES, SLOANE'S GROVE, TRESCO. pH Value.

——	H. elect.	Sb elect.	Q.H. elect.	Probable P.H.
0–6″	8·49	8·30	8·84	8·49
6″–12″	..	8·57	8·86	8·57
12″–24″	9·14	9·00	8·93	9·14
48″–60″	..	10·03	9·23	10·03
60″–72″	10·00	10·04	9·28	10·00

Determinations made by R. J. Best, Waite Research Institute.

Replaceable Bases.

There are very striking differences between the replaceable bases of the three types of soil. Table 10 shows the content of total replaceable bases expressed as milligram equivalents per 100 grams of soil; and the percentage of calcium, magnesium, sodium, and potassium in this total.

It will be seen that total bases are low in type I. high in type III., while type II. is intermediate. Very important differences occur also in the percentages of the four bases. Calcium is very much higher in type I. In the top 3 feet it contributes 73 to 48 per cent. of the total, while in the second 3 feet it falls between 20 and 30 per cent. In type II. the top 3 feet show 56 to 20 per cent., and only about 10 per cent. in the lower 3 feet. In type III. the figures are respectively 55 to 10 per cent. in the upper, and less than 10 per cent. in the lower layers. Type III. is thus the lowest in calcium.

Sodium on the other hand is lowest in type I., and highest in type III., especially in the root zone, 0-36 inches. In type I., 0-36 inches it falls between 5 and 11 per cent., and from 36–72 inches, 22 to 44 per cent. In type II., 0–36 inches, it varies from 10 to 14 per cent., and at 36–72 inches, 37 to 49 per cent. In type III., 0–36 inches, it is extremely high, 28 to 62 per cent. The layers, 36–72 inches, contain 49 to 59 per cent. of their replaceable bases as sodium.

Magnesium is more important in type II. than in either of the other types. In two instances it is seen to be the major base present. In type I. it is unimportant, being substantially lower throughout than calcium. In type III. it is present in about the same actual quantities as in type II.; in fact, it is higher from 4 to 6 feet; but the very high

Table 10.

Replaceable Bases in Tresco Soils Per cent. and Total Bases Expressed as M.gm. Equivalents per 100 gms. Soil.

——		0–6″.	6″–12″.	12″–24″.	24″–36″.	36″–48″.	48″–60″.	60″–72″.
Type 1—		%	%	%	%	%	%	%
Malcolm's Good Grove [2 A] ..	Ca. ..	73·0	62·4	60·6	48·3	32·6	19·6	28·4
	Mg. ..	10·8	16·0	14·4	21·1	26·6	16·4	16·7
	Na. ..	5·7	11·4	11·5	10·0	21·7	44·3	35·7
	K. ..	10·5	10·2	13·5	20·6	19·1	19·7	19·2
Total bases in M.gm. equiv. per 100 gms. of soil		10·05	11·32	12·59	9·67	9·97	13·14	10·83
Type 2—								
Sloane's Affected Grove [10 A] ..	Ca. ..	56·6	54·28	27·86	19·51	9·96	11·50	12·45
	Mg. ..	23·0	27·10	38·13	37·14	41·21	29·49	31·53
	Na. ..	12·3	10·02	21·49	40·88	37·20	49·27	45·12
	K. ..	8·1	8·60	12·52	2·47	11·63	9·74	10·90
Total M.gm. equiv.		16·83	17·56	14·61	17·37	14·95	20·52	17·51
Type 3—								
Counsell's Salt Pan [19 A] ..	Ca. ..	52·24	37·26	22·86	10·34	7·67	9·45	10·01
	Mg. ..	12·68	12·06	19·86	22·39	27·40	29·95	33·52
	Na. ..	28·21	44·77	51·48	62·17	59·50	55·16	48·85
	K. ..	3·87	5·91	5·80	5·10	5·43	5·44	7·62
Total M.gm. equiv.		30·20	26·69	24·67	25·91	24·27	32·17	29·97
Type 2—			0–12″					
Unirrigated [11]	Ca. ..		70·8	35·3	25·0	22·5	22·8	19·4
	Mg. ..		18·3	34·5	34·4	36·6	37·4	33·9
	Na. ..		6·8	26·9	36·5	31·2	33·0	39·1
	K. ..		4·1	3·3	4·1	9·7	6·8	7·6
Total M.gm. equiv.			23·63	19·69	17·85	17·90	15·65	18·73

sodium content of type III. reduces the percentage of magnesium in the replaceable bases.

In general, it may be said that the subsoil of type II. is mainly a sodium magnesium clay, both occurring in about equal proportions; while that of type III. is also a sodium magnesium clay, but sodium is much the higher.

Potassium occurs in about the same actual amounts in all three types; but in type I., owing to the much lower contents of sodium and magnesium it rises to 20 per cent. of the total bases, a very high figure indeed for potassium. Whereas in type II. it reaches only 12 per cent., and in type III., 7 per cent.

We see that the most fertile soil, type I., has the lowest replaceable base content. This is not usual, for the most fertile soils, as a rule, have a high content (19). In this case the higher values, however, are largely composed of sodium and, to a less extent, magnesium. Calcium, the base which usually preponderates in a fertile soil (10), (19), (25), being very low except in type I. These differences are responsible to a large extent for the great physical differences between the types.

The various replaceable bases in the soil zeolites and humus exert a profound influence on the condition of the soil. The bases which concern us at Tresco are, as we have seen, calcium, magnesium, sodium, and potassium.

A normal European soil (19) contains in its replaceable base fraction approximately 75 to 90 per cent. calcium, 10 to 15 per cent. magnesium, and a small percentage of sodium and potassium, while several neutral or slightly alkaline Californian soils (25) contain 50 per cent. or more calcium, 20 to 30 per cent. magnesium, and very little sodium and potassium.

These soils are possessed of desirable physical qualities. They are readily permeable to water, have a relatively low viscosity, and do not swell extensively when wet. In broad terms, they are good friable soils. When, however, the predominating base is sodium, as at Tresco, types II. and III., and in alkaline soils generally, the soil becomes very plastic and viscous when wet, swells extensively, and is relatively impermeable to water (1), (7), (11), (14), (19), (26), (27), (38), &c. These agricultural differences are due to essential differences in the character of the colloids. The colloidal particles of the calcium saturated compound tend to aggregate together to form large particles—an "amorphous" colloid.

The sodium saturated complex, however, tends to be strongly dispersed—the particles splitting up into particles of true colloidal dimensions—a hydrophilous colloid or "gallert" (8).

The magnesium and potassium compounds are intermediate. The magnesium is nearer to the calcium type; while the potassium resembles sodium in its properties (12), (13). Of these bases potassium has not yet been recorded as the dominant in any soil studied, and is very rarely as high as 20.6 per cent. as in type I.

The impermeability of the subsoils of the affected groves, and the water table formed, as a result of irrigation, may therefore be attributed largely to the high sodium, and perhaps, to a less extent, magnesium in their replaceable bases.

From the point of view of plant nutrition, it has been shown (16) that calcium occupies a special place amongst the replaceable bases, and it seems probable that its extensive replacement by sodium may exert an influence on the metabolism of the plant quite apart from its effect on the agricultural properties of the soil—a field of work, as Gedroiz points out, quite unexplored as yet.

Discussion of Soil Investigation.

As a result of this investigation, it appeared that the unthrifty condition of citrus trees at Tresco could be attributed to one or more of the following factors:—

1. A water table occurring in the root zone.
2. High salinity in the root zone, especially the surface layers.
3. High alkalinity.
4. Lime induced chlorosis.

It was decided to take over the control of Mr. A. Sloane's grove, and attempt a reclamation of the soil along the following lines:—

(i) The water table being due largely to faulty irrigation methods, it was decided to experiment with better systems of distribution of water.

(ii) As ample drainage outfall is provided for most groves at Tresco, it was thought advisable to test the efficacy, in removing this free water, of tile drains laid at depths of 6 feet and shallow drains 2 ft. 3 in. from the surface as compared with drains of the depth

usual at Tresco, 3 ft. 6 in. It will, of course, be borne in mind that, owing to the necessity for using liberal quantities of irrigation water for salt leaching purposes, the method of removing the water table by withholding irrigation water was not open to us. The drains at 2 ft. 3 in., it was thought, might remove much of this leach water before it penetrated to the lower layers and produced a water table.

(iii) The use of growing crops between the rows of trees to control the water table suggested itself, and has been extensively studied.

(iv) To lower the soil reaction, and to endeavour to increase the soil content of replaceable calcium top-dressing with gypsum, of which there are extensive surface deposits in the immediate vicinity, was tested. On another grove a trial was made also of the comparative merits of sulphur and gypsum from this point of view (23), (29), (30), (39). It was thought that the gypsum, if effective, would facilitate the control of the water table by increasing the permeability of the subsoil and thus its drainage properties (18). It was also realized that leaching with comparatively fresh water, in the absence of calcium salts might actually increase the impermeability of the soil, by permitting the more ready hydrolysis of the sodium zeolites when the sodium chloride concentration was lowered by flood irrigation (9), (24), (26), (45).

(v) Flood irrigation (the border and the basin systems have been used) was tried in comparison with the furrow system which, prior to the investigation, had been standard in the district. It was thought that much of the soluble salt might be leached out of the soil by flooding and tile drainage; but that, supposing it were not possible to leach the salts from the block in this way, then it might be possible by flood irrigation to disperse the salt in depth, and so lower the maximum concentration in the root zone. This has involved the exact measurement and analysis of the irrigation water applied, and the output from each drain for the past five seasons, together with boring and analysis of the soil of the grove at frequent intervals.

(vi) As has been stated in the text, the introduction of ferrous salts in various ways has been tried on a number of affected trees, in order to see if the chlorotic appearance, possibly due to the high amount of calcium carbonate present, could be corrected by these means.

(vii) The importance of organic matter in soils of this type has been stressed by many workers both in the conversion of the more toxic sodium carbonate to the less toxic sodium bi-carbonate; and in highly calcareous soils it tends to lower their chlorotic effect (6), (17). Thus a green crop of peas and beans has been sown each autumn and ploughed under in spring, not only for the control of the water table by transpiration, but also for the addition of humus.

Of these experiments, those dealing with the methods of irrigation have been fully dealt with in a previous report (34). The remainder will be communicated subsequently.

Citrus Nematode.

The Citrus Nematode (*Tylenchulus semipenetrans*) identified by Mr. D. B. Adam, Plant Pathologist of the Department, occurs abundantly on the roots of citrus trees at Tresco. This nematode partly buries itself in the tissues of the fibrous roots, and sucks its nourishment from them. In this way it has been found to impair the health of infected trees (43).

Its influence on tree health at Tresco is somewhat obscure. It occurs in abundance on both good trees and poor. Thus N. H. Malcolm's and R. A. Phillips' good trees are heavily infected, although their fibrous root systems are so abundant that many rootlets are free of nematodes. All the unhealthy trees examined were found infected, but in their case the fibrous root system is invariably scanty, and there are practically no roots free from attack.

Mr. G. Chapman's grove is the only sound one on type II. soil. It is practically free from nematodes. It may be that, on soil which is chemically and physically suited to the growth of citrus, the trees growing vigorously, and possessing a large leaf area, can send out new fibrous roots as fast as, or faster than, the nematodes can impair their efficiency. If, however, the tree receives a setback in a soil which becomes too saline for optimum growth, it soon becomes rather thin in the foliage, and the leaves, from their chlorotic appearance, are seen to be relatively inefficient. Under such conditions, it is probable that the fibrous roots are injured by the nematode at a faster rate than new ones can be grown.

In other words, adverse soil conditions possibly can alter that balance which permits a normal tree to grow in association with the

nematode; and when this balance is upset, the nematode may definitely contribute to the ultimate death of the tree. It is significant that the only good grove on type II. soil is free from the organism, or practically so.

If it be true that citrus trees can not grow on type II. soil where the nematode is present, the reclamation of such areas to successful citrus-growing is impossible, for the organism can live in the soil after the removal of the trees for many years. And even were it possible to eradicate it before replanting (and it is not), the young groves would soon become reinfected through the irrigation water, and the wheels of vehicles and implements, &c., coming on to them from other parts of the settlement.

It is hoped, however, that on soil such as Sloane's which, as the result of reclamation work referred to (to be reported subsequently), has been brought to a chemical condition apparently suitable for citrus-growing, the replanting with young orange trees will be successful. This replanting has just been carried out, and every attention will be given to the trees. The outcome is open; but it can be looked to with intense interest.

The nematode survey is proceeding, and as occasion offers is being extended to other districts. The above remarks are only tentative.

Summary.

1. An investigation of the soil conditions associated with the non-thrifty condition of citrus trees on the Tresco settlement has been made.

2. Three soil types have been distinguished. These soils are all of the same class, but vary in texture. Tree health has been found to diminish, usually, with increasing heaviness of the soil.

3. A free water table within a few feet of the surface is associated with the trouble on many groves. It has been found to be a result of the inefficient distribution of irrigation water, and the very impervious nature of the subsoil. This water table is a purely local one on most blocks, and of a temporary nature.

4. There is evidence that at a greater depth, about 20 feet, a permanent watertable underlies the whole countryside.

5. Water soluble salts, of which sodium chloride is the most important, have been found to increase as tree health diminishes. The opinion is expressed that a concentration of chlorine of 30 parts per 100,000 of dry soil is probably inimical to the health of citrus trees, in this district, and that on most groves this factor has been in operation.

6. Chloine concentrations increase in depth, and at 20 feet, approximately the maximum depth reached in boring, a concentration of 200 to 500 parts per 100,000 is usual. The importance of this saline horizon is discussed, and the conclusion reached that if irrigation practice be adjusted to meet such conditions, these deep saline layers need not be feared.

7. Routine soil analyses disclose no very obvious difference between the good and the poor groves to which the condition of the trees on the latter could be attributed, although the higher lime content may be inducing chlorosis.

8. The hydrogen ion concentration on all soils is high, and in many cases is possibly contributing to the trouble; but no clear cut relation between p.H. and tree health is discernible.

9. In their replaceable bases the three soil types differ markedly. The good soil is associated with relatively high calcium, especially in the root zone (50-75 per cent.), and relatively low sodium for the soils of this region. The poorest soil is associated with relatively low calcium and very high sodium (30-62 per cent.). In the intermediate soil type calcium and sodium values are between these two extremes, but magnesium is much higher than in either the better or the poorer soil.

10. The importance of these replaceable base considerations is discussed, and it is concluded that the impermeable character of the subsoils of types II. and III. is due mainly to their high contents of replaceable sodium.

11. The position, in the light of the soil investigation is briefly discussed, and an outline is given of the experiments in reclamation which were initiated at the conclusion of this survey. These experiments will be subsequently reported.

12. The citrus nematode (Tylenchulus semipenetrans) occurs abundantly at Tresco. Its relation to tree health is obscure, since it occurs on both good and affected trees. Certain aspects are briefly and tentatively discussed.

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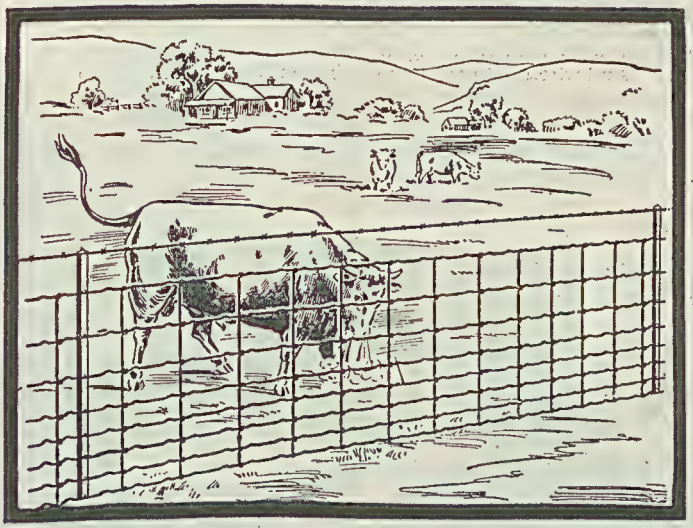

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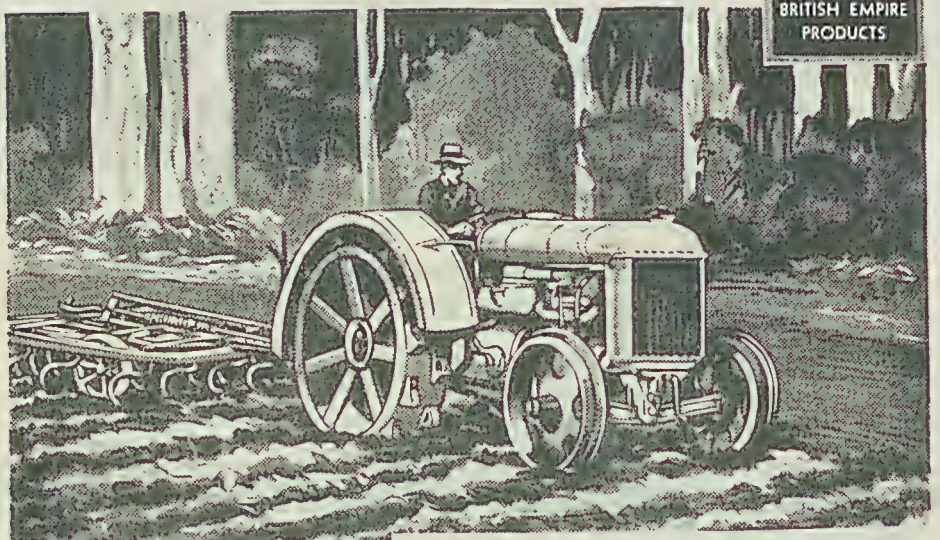

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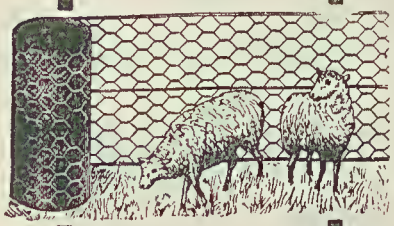

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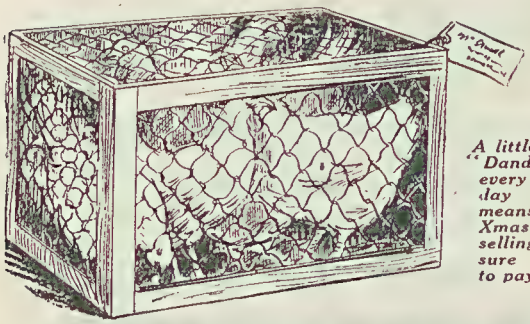

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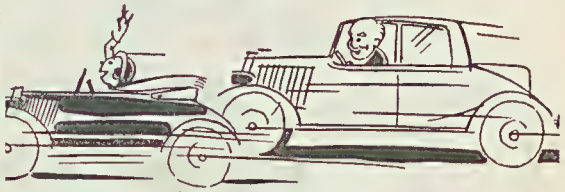

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Dam ... ... Victoria Braid (1654 A)

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3. *Born* ... ... 11th February, 1931
Sire ... ... Dominion Bright Belgian
Dam ... Victoria Euphrates (716 A)

24 Guineas

4. *Born* ... ... 28th August, 1931
Sire ... ... Dominion Bright Belgian
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